Enhancing the Implementation of Safety Engineering Systems in Oil and Gas Construction Projects in the UAE

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Abstract

Risk assessment is one of the most critical methodologies used in the safety engineering system in oil and gas construction projects that require high levels of precaution in construction activities such as pilling, materials fabrication, and structure installation. The main purpose of risk assessment is to provide full protection to the four main elements that are crucial to the oil industry: People, Environment, Assets and Reputation (PEAR). Any failure or defect in the risk assessment implementation can potentially lead to catastrophes not only during the construction stage but also in the advanced stages such as operation and productions. Historically, in oil and gas construction projects many oil spills and blow outs occurred due to lack of efficient risk assessment in the construction phase, resulting in financial loss and human capitals. The aim of this research is to enhance the implementation of safety engineering systems in the oil and gas industry construction projects through risk assessment application in the UAE. Firstly, the aim is achieved via conducting a questionnaire to determine the current defects in the risk assessment applied methodology in the safety engineering system. Secondly, interviews are conducted with safety construction professionals to examine top risk factors in UAE oil and gas construction projects. After that, a framework to enhance the application of risk assessment and optimize safety engineering system is proposed based on the results found during the questionnaire and interviews phases. Finally, qualitative and quantitative validation of the proposed framework is applied to strengthen its feasibility and mechanism. This research study contributes to construction safety knowledge by studying behavioral safety performance and its critical role in risk assessment implementation. The main outcomes of this research study expose a gap in the understanding and the practices of risk assessment methods between management and workers, especially with regard to human factors effects on safety performance. In addition, this study recommends using proactive KPIs to measure the safety culture in the construction site in which it gives the chance to conduct early correction actions before the occurrence of the incidents.

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Finally, this research work is dedicated to all workers who involved daily in the fight against the poor safety performance of the construction industry.

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“*There is no god except You. All Extolment be to You! Surely, I have been of the unjust.”*

Al anbiya (87)

To my daughter, my angel, Shamsa

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Glossary of Terms

ALARP: As low as reasonably practicable

BOP: Blow Out Preventer

ETA: Event Tree Analysis

EPA: Environmental Protection Agency

FMEA: Failure Mode and Effect Analysis

FRA: Fatal Accident Rate, number of fatalities per 1,000,000 working hours

FTA: Fault Tree Analysis

HSE: Health, Safety and Environment

HSE-MS: Health, Safety and Environment Management System

LTI: Lost Time Injury**,** sum of number of fatalities and work lost day case

LWCD: Lost Work Case Day, any work injury other than fatality which makes the person unfit for a day or more after the injury day

MHSWR: Management of the Health and Safety at Work Regulations

MMS: Minerals Management Service

OGP: International Association of Oil and Gas Producers

OSD: Offshore Safety Division

PSR) Pipeline Safety Regulations

PEAR: People, Environment, Assets and Reputation

PFEER: Prevention, Fire & Emergency Response Regulations

PTW: Permit to Work system

RWCD: Restricted Work Case Day, any work injury other than fatality or (LWCD) which results in person being unfit for full performance for the regular job

TRIR: Total Recordable Incident Rate, A measure of the rate of recordable workplace injuries, normalized per 100 workers per year

List of publications from this thesis

1. G.Kashwani, & Y. Nielsen. “Evaluation of Safety Engineering System in Oil and Gas Construction Projects in UAE,” International Journal of GEOMATE, Vol. 12 No.29, 2017, pp.178-185.

Chapter 1: Background

1.1. Introduction

Construction is a very dynamic and complex industry, facing numerous challenges. According to Reyes et al. (2014), Health and Safety (HS) concept can play a vital role in preventing and mitigating all critical risk factors and this only can be achieved by ensuring the implementation of HS matters in the whole construction project life cycle. Reyes et al., believe that construction industry has a high accident rate compared to other industries due to the complexity of construction factors, possessing a social, human and economic dimension. Haslam et al. (2005) provide examples of these dimensions, listing inadequate training, large number of subcontractors, lack of proactive culture, and an inadequate risk assessment. Haslam claims that these negative factors can be prevented and controlled in the design phase before they escalate and affect the whole project. This can be achieved through accurate hazards identification techniques such as Task Risk assessment (TRA), Hazard Identification (HAZID), and Hazard and Operability Study (HAZOP). Cheng et al., (2012), however, suggests that all HS matters in the organization can be addressed and implemented effectively if there is a specific system such as Health, Safety and Environmental Management System (HSE-MS). Cheng et al., explain that in any construction project, safety engineering system has become critical to construction due to the legislative and regulatory requirements in the country along with the company’s reputation and social responsibility.

Usually in construction and operations sites, a multitude of safety problems occur frequently each year, leading to personal injury and may permanently affect employee’s long-term health (Young & Yonghua, 2004). In order to improve safety engineering system and reduce accidents as well as personnel injuries, HSE-MS must be constantly improved at construction sites. HSE-MS in construction sites ideally should contain the concepts and principles that are used in the development and management of an effective HSE program. The HSE-MS plan should be continuously improved with particular emphasis on organizational accident prevention in construction sites (Mikkelsen et al. 2004). For example, special attention should be given to elements such as morale influence, education and training, the role of the supervisor, inspections, auditing, policies and risk assessment.

Coble et al., (2000) mention that risk assessment is one of the most vital elements in addressing all the HS engineering matters of the construction building project life cycle where internal factors can have direct influence on the risk assessment implementations. Internal factors that may affect the risk assessment implementation in the construction company are insufficient communication, perceived budge viability and production/time pressure. Coble et al., propose best management practices that are mostly related to management leadership which can increase the awareness level internally at construction organization. In the end of their research, the authors encourage researchers to study the effects of external factors such as new technologies and their effect on the risk assessment implementation in the construction building projects.

1.2. The history of safety engineering system in oil and gas construction projects

The Organization of Petroleum Exporting Countries (OPEC) recognizes the United Arab Emirates (UAE) as one of the leading countries in the oil and gas industry in the Middle East and the world where it owns around 10% of the world's total crude oil reserves (OPEC, 2016). According to OPEC's annual statistical report in 2016, the crude oil export rate for UAE is 2.9 million barrels per day (b/d) where the production rate of the onshore oil and gas construction rigs is around 1.8 million (b/d). UAE is ranked as the fourth largest gas reserves country in the world for the gas production after Russia, Iran, and Qatar (Salama et al., 2008). The oil and gas industry in UAE witnesses a continuous improvement and development in the production rate as shown in Table 1.

Table 1: Crude Oil production for UAE (OPEC, 2016).

Year	Production rate Million (b/d)
1984	1.0
1986	1.1
1989	1.6
1990	1.8
1991	2.0
1998	2.2
2016	2.9

According to Salama et al., (2008), the efficiency of the oil and gas construction projects from 1980 until the present time plays a vital role in enhancing the production rate. The oil and gas construction projects in UAE are divided into three main categories; onshore, offshore and pipelines where around 90% of these construction projects are located in onshore fields. There are several activities that can take place at the constructions sites including but not limited to materials fabrication, structure installation, etc., which are performed at the required phases (e.g. exploration or production). All these construction activities are associated with serious hazards such as working at height and dropping objects due to the hydrocarbon materials existence. For instance, fire, explosion, and blow out can be critical hazards that can lead to fatalities.

Oil and gas construction projects have witnessed many historical catastrophes that eventually laid the groundwork for professional practices to the industry (Davies, 2010). These serious safety failures increased the oil and gas construction world awareness towards safety implementation in the construction activities such as structure installation, foundation pilling, and materials fabrication. This is due to the different economic and environment loss that oil and gas construction industry suffered due to these accidents. According to Cohen, (1995) financial damages in oil and gas construction can have a major impact on the company's profit profile since these damages link directly with decrease in production and downtime losses. For the environment damages, Ronza et al., (2009) believe that oil and chemical spills are the main environmental threats in the oil and gas construction projects damaging vital ecological elements such as soil, natural habitat, and marine life. Surprisingly, Ronza et al., mention that the oil and gas construction companies often fail to comply with environmental performance until the regulatory authorities like Environmental Protection Agency (EPA) start imposing penalties and fines. These legal penalties presented the wake- up call to the whole oil and gas industry to adopt proper methods to control hazards at construction sites. As a result, the oil and gas construction industry adopted risk assessment methods from other industries so as to ensure efficient control and mitigation process (Aven, 2009).

1.3. The history of risk assessment in oil and gas construction projects

The oil and gas construction projects pose high risks to both staff and workers if appropriate controls are not in place. Hence it is important to use risk assessment in the safety system to mitigate the possible hazards that exist in the work environment. UAE is one of the leading countries in the oil and gas construction projects in the Middle East and the world. UAE companies in oil and gas construction projects use very advanced risk assessment applications in their safety engineering systems as shown in Table 2:

Table 2: Risk assessments that are used in oil and gas construction rigs in UAE.

Risk Assessment and Management Procedures
Health, Safety and Environment Impact Assessment (HSEIA)
Escape, Evacuation and Rescue Assessment (EERA)
Hazard Identification (HAZID)
Hazard and Operability (HAZOP) Study
Qualitative Risk Assessment (QLRA)
Control of Major Accident Hazards (COMAH)
Major Accident Hazard Analysis (Bowtie Analysis)
Manual of Permitted Operations (MOPO)
Occupational Health Risk Assessment (OHRA)
Task Risk Assessment (TRA)
Quantitative Risk Assessment (QRA)

Unfortunately, risk assessment applications in safety engineering systems have been developed after numerous serious incidents where inadequate poor communication in the construction phase was the root cause for these incidents. According to Davies (2010), many of these serious incidents occurred in the operation phase that could have been controlled had the risk assessment been effectively implemented in the construction stage.

- Alexander L. Kielland capsize (North Sea, 1980)

  Due to fatigue cracks that caused major collapses in the bracing members of the rig structure, 123 workers were killed in this fatal accident. According to Moan, (2007), the main technical failure that lead to this huge accident occurred in the design phase where load distributing was not measured correctly thereby it affecting the welding mechanism. In addition, the author believes that escape and evacuation process were not carried out efffectively due to the poor emergency preparedness and limited access. For example, there was only one life boat that was launched to safe more than 80 workers.

- Ixtoc I. Blowout (Gulf of Mexico, 1979)

  Boehm and Fiest, (1982) consider Ixtoc I. Blowout disaster to be one of the historical spills in the oil and gas construction industry. It caused a massive contamination area (180 km x 80 km) due to a well control issue during the operation. It is clear that there was no equivalent point between hydrostatic and formation pressures where the increase in the formation pressure generated a fluid kick that later developed into a blowout. According to the authors, technical failures in the well head design affected Blow Out Preventer (BOP) function and led to loss control of the well. As result, around 3.5 million barrels of oil spilled into the Gulf of Mexico.

- Piper Alpha Explosion (North Sea, 1988)

  Davies (2010) mentions that Piper Alpha accident is considered one of the most famous fatal accidents in the oil and gas business industry. 167 workers lost their lives in this tragedy due to the removal of a safety valve from a compressor, resulting in a gas leak which caused a major fire. However, Davies believes that apart from this active failure (direct cause), other technical, procedural and behavioral causes played a critical role in escalating this catastrophe. The following point represents the latent failures as mentioned in American Petroleum Institute (The Lessons of Piper Alpha, 2009):

  1. Lack of effective communication between crew member (behavioral)

2. Not applying Permit to Work system (PTW) adequately (procedural)
3. Continued pumping of gas and oil by the Tartan and Claymore platforms (Technical)
4. Poor emergency plan

- Deepwater Horizon Blow Out (Gulf of Mexico, 2010)

  11 workers were killed and more than 4 million barrels of crude oil was spilled in Gulf of Mexico due this huge blowout. According to Rathnayaka et al. (2013), the main technical failure that led to this catastrophe was inadequate cementing in the completion phase that marred the well control process. It is clear that, due to the poor quality of cementing in the down hole during construction and high formation pressure, hydrocarbons were released and reached all the way to the drilling column causing an explosion where it was hard to control the kick by BOP because of the its high volume. In addition, the authors state that other invitation reports indicated safety management failures such as leadership, communication and managing resources were classified as root causes for this fatal accident.

In oil and gas construction projects, any failure in the risk assessment could lead to major catastrophes (Hauge et al. 2014, Elshorbagy et al. 2008, Shahriiar et al. 2012). Risk assessment examines closely all the activities that may take place in the oil and gas construction projects. The main purpose of risk assessment is to provide full protection to the four main elements that are of utmost importance to the company i.e. People, Environment, Assets and Reputation (PEAR) from any harm in the work place (Aven & Vinnem, 2007) as shown in Fig. 1.

Figure 1: Risk Assessment seeks to improve the four (PEAR) elements.

The history of risk assessment started with the insurance companies that are associated with The Industrial Revolution, which took place from the 18^{th} to 19^{th} centuries, in different businesses (American Bureau of Shipping, 2000). When large capital investments were made in the industrial business, it was necessary to understand, manage, control and calculate the risk. In the beginning of 1980, EPA required a worst environmental scenario description in the application for the entities who are applying for the environmental permit. After that, other agencies started to implement the concept of risk assessment. For example, the Minerals Management Service (MMS) in United States 1982 had developed the environmental and safety regulations for offshore oil and gas industry (Scarlett et al. 2011). Soon after, the awareness of the importance of risk assessment increased in the industrial businesses, especially in the oil and gas industry due to its association with multiples hazards.

In the beginning, the concept of risk assessment pertained to be more perspective based regulation and then developed to performance based regulation. It is clear that, in perspective regulation, the assessment of risk will be more in terms of equipment and the technologies used in the event without defining and analyzing the risk itself, which is the case of risk based on performance regulation. The risk based on performance regulation has evident role in controlling, analyzing and mitigating the risks. For instance, when the risk assessment is developed, most of the risk assessment techniques classify the risk based on its severity and frequency and then they propose mitigation plans to control the hazards.

Unfortunately, usually the development of risk assessment in oil and gas field comes after the occurrence of serious incidents. For example, following the Alexander Kielland accident in the Norwegian offshore rig in 1980, the petroleum authorities in Norway required that risk assessment had to have risks with a probability higher than once every 10,000 years (Norwegian Petroleum Directorate,1989). This is very similar to other real incidents in which the main lesson learned was to strengthen risk assessment, thus enabling risk assessment to take a major role in every oil and gas construction company regulations. This demonstrates the growth of risk assessment from usage as method to a mandatory regulation to any hydrocarbon operating facility.

This development leads to have an advanced risk assessment in the oil and gas construction companies whether they are contractor or construction companies. It is clear that risk assessment and management formed the most important element in the HSE management system where all other HSE elements should work in favor of risk assessment and management element (Aven & Vineem, 2007). As such, risk assessment is involved in almost every activity in oil and gas construction projects. For example, risk assessment should be used in planning, designing, piling, structure installation, and waste management. This variety of risk assessment usage provides engineers and planners the chance to use risk assessment in different techniques and methods. For instance, a number of technical methods (qualitative and quantitative) have been used for risk assessment in oil and gas construction rigs such as Failure Mode and Effect Analysis (FMEA), Hazard and Operability Study (HAZOP), Fault Tree Analysis (FTA) and Event Tree Analysis (ETA) (Khan & Abasi, 2001). All these methods cover the basic concept of risk assessment which is to have a systematic way to predict and prevent unwanted events during oil and gas construction projects.

1.4. Rationale

According to experts in oil and gas construction projects and in reference to previous accidents in other hydrocarbon fields, the possible causes of accidents are analyzed by first identifying the root causes of the accidents through risk assessment. Root cause analysis through risk assessment provides a great learning opportunity so as to continuously improve the HSE management by examining what went wrong (ISO, 2008). The development of risk assessment helps reduce the serious incidents that occurred in the oil and gas industry such as blow outs, pipe leaks, and toxic gases release in which most of risk assessment that are currently in the oil and gas industry cover the following aspects (Vinnem, 1998):

- Estimation of risk acceptance criteria
- Determining design loads and conditions
- Understanding of hazards causation and potential escalation pathways
- Ranking of hazards according to risk potential
- Providing emergency plans and responses

This positive impact of the risk assessment has a global effect in the international oil and gas construction rigs whether onshore or offshore as shown in Fig. 2 which is taken from The International Association of Oil & Gas Producers report, (OGP, 2011).

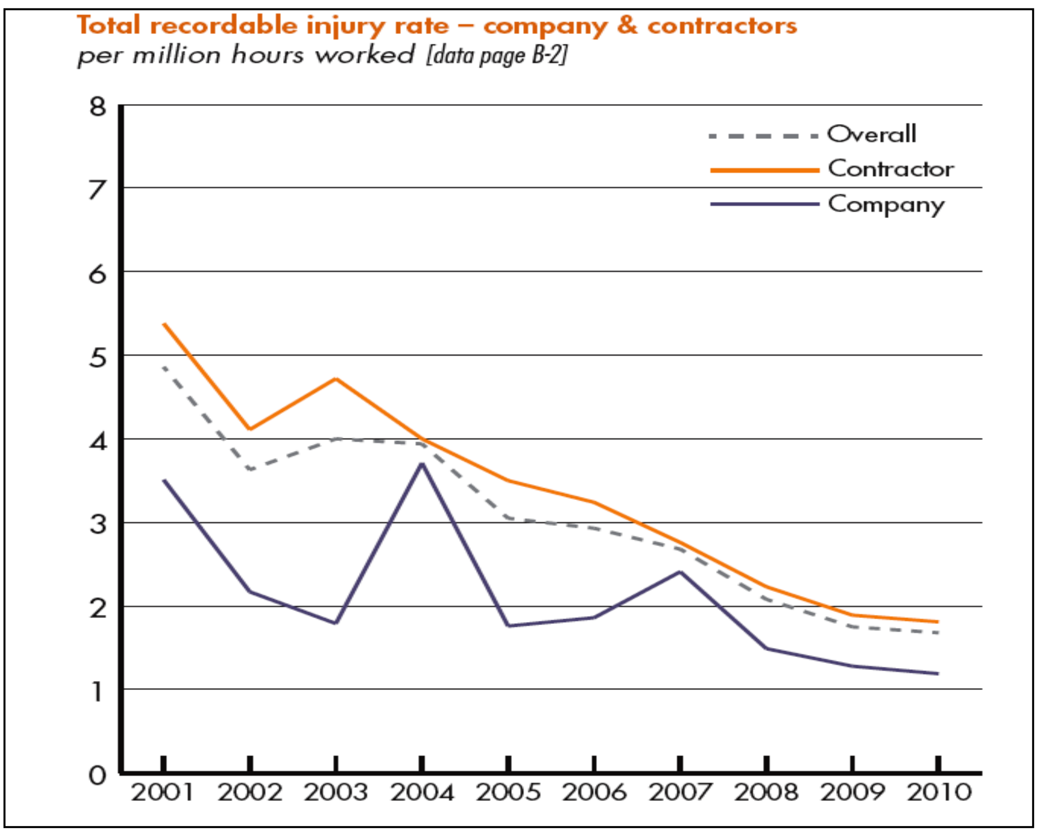


Figure 2: (TRIR) – Companies (owners) and contractors (service providers) 2001-2010 (OGP, 2011).

Fig. 2 shows all Total Recordable Injury Rate (TRIR) for all international oil and gas construction companies (owners or contractors) between 2001 and 2010, clearly emphasizing the huge improvement in safety performance. It is clear that, the overall TRIR was 1.75 in 2009. This is a 64% improvement compared with 2001, where the TRIR was 4.90. Also, Fig. 2 displays how oil contractor companies have a higher number of accidents than owner or construction companies.

As explained earlier, the risk assessment has strengthened gradually over time; concurrently the HSE performance for the oil and gas construction companies also has undergone gradual enhancement globally. Table 3 shows the Lost Time Injury Frequency (LTIF) record for the oil and gas construction companies in each region from 2006 to 2010. As shown in the table, the Middle East has the best LTIF record compared to other regional areas.

Table 3: LTI records from 2006-2010 (OGP, 2011).

	2010	2009	2008	2007	2006
Africa	0.36	0.42	0.61	0.64	0.66
Asia/Australasia	0.29	0.29	0.29	0.27	0.36
Europe	1.06	1.31	1.38	1.40	1.65
FSU	0.31	0.35	0.45	0.57	0.78
Middle East	0.25	0.26	0.29	0.50	0.68
North America	0.48	0.51	0.55	0.68	0.85
South America	0.61	0.69	0.90	1.08	2.08
Overall	0.42	0.45	0.55	0.66	0.99

The numbers shown in Table 3 indicate that safety performance has improved between 2006 and 2010 in the entire world and that risk assessment is functioning in an effective manner. Other statistics, however, show risk assessment implementation issues at which problem still exists in the safety engineering system. For example, in 2010, OGP, (2011) report mentions that the top 10 casual factors that assigned to fatal incident were related to risk assessment and its implementation such as inadequate, communication, training, competence, hazard identification and supervision.

Risk assessment implementation is not a new challenge for the safety engineering system in the oil and gas industry, where many famous cases studies of failed risk assessment result from a lack of risk assessment implementation. For example, the Control of Major Accident

Hazards (COMAH) report by HSE 2011 mentions that the root cause of the 2005 Buncfiled explosion (Oil storage) in Hertfordshire Oil Storage Terminal was the lack of the safety implementation in the construction design stage. The report mentions that the safety implementation measures that should be taken were fuel escaping safety measures. This would have helped prevent escape of flammable vapour and stop pollutants from poisoning the environment. Moreover, the report mentions the following points to cover the gap in safety/risk assessment implementation:

- Safety management was not conducted for critical equipment
- Working hours load on the staff was high and employee welfare should be considered
- Poor communication between designers and suppliers in the usage of the critical equipment
- Environmental response plan was not in place as it is recorded in the emergency plan
- Visibility and leadership were not presented and implemented in an effective way in the safety management

When one examines the investigation report, it appears that the risk assessment implementation issues impact not only the construction stage but also primary stages like policy setting, planning, committed leadership development, and visibility of the company. It is clear that, risk assessment implementation may not be so visible in these stages but it poses a direct connection with operational implementation. For example, high profile management involvement in the safety activities should appear in the following safety events; meetings, awareness campaigns, audits, and inspections. This will set a good example for the operation employees (end-users) to place safety on the top of their priorities when performing their jobs.

There are statistics showing that the UAE oil and gas construction rigs face the same challenges towards risk assessment implementation. Al Kurdi (2008) believes that the first reason behind incidents in oil and gas construction in UAE is due to the lack of safety engineering implementation. Al Kurdi believes that there is a necessity to provide an integrated framework that can enhance the implementation mechanism. Fig. 3 presents numbers supporting Al Kurdi assumption that the poor implementation of risk assessment and its elements are the main reason for incidents in all oil and gas construction projects in the UAE (ADCO, 2012).

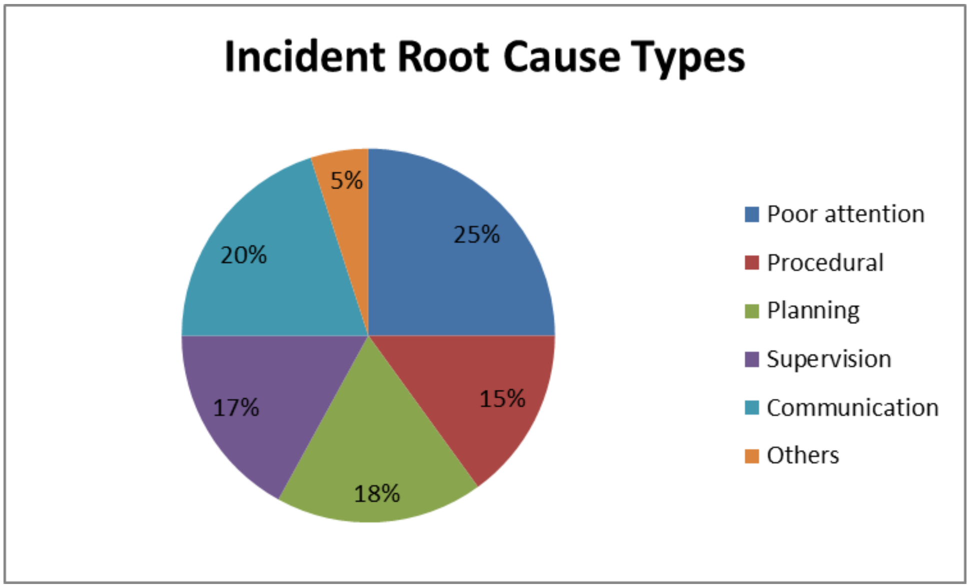


Figure 3: Incident Root Cause Types (ADCO, 2012).

The conclusions made above regarding poor implementation of risk assessment as the main reason for many incidents indicates that the UAE oil and gas construction are facing difficulties in risk assessment implementation in the same way as many other oil and gas industry countries suffer. This leads to many questions that require answers on how the current risk assessment is used in the oil and gas construction rigs. For instance: why do other international oil countries have good safety performance but UAE's oil and gas construction have issues in safety performance even though they share the same risk assessment? Are there defects in the current process that need to be solved in the risk assessment? What are the challenges that risk assessment face in UAE oil and gas construction projects?

1.5. Significance of the study

Risk assessment implementation poses a multi-pronged issue, such as technical, procedural and behavioral. In the studies that have been conducted on the risk assessment for oil and gas construction rigs, it can be inferred that these studies aim to enhance the effectiveness risk assessment by creating numerical or algorithm models using the quantitative or qualitative risk assessment. Upon review of the literature on risk assessment, it can be concluded that previous studies focused on the mechanism of the risk assessment and hazard identification that are used in the oil and gas industry such as FTA, HAZOP, and EIA. The implementation problem contains different aspects and in the literature reviews there is no specific study that focuses on the risk assessment implementation problem directly. Thus, to answer the question why people do not implement the safety rules that come from risk assessment, different factors should be analyzed in the risk assessment structures and how the system is very closely linked.

In addition, during this study the relationship between human factors and safety engineering system will be highlighted. For example, human factors have a major effect on the risk assessment implementation because it is linked to the individual behavioral safety that interacts with work environment, technical and procedural processes in the construction stage. According to Gordon et al. (2005) there are possible threats to human factor that need to be covered during the evaluating the performance of human factors towards safety. Gordon et al., explains that the threats are related to factors that affect the individual behavioral safety such as organizational safety culture, safety leadership, competence and training where these factors can show the reliability of human factors on risk assessment methods.

1.6. Aim and objectives

The aim of this research is to enhance the implementation of safety engineering systems in the oil and gas industry construction projects through risk assessment application in the UAE. This aim will be achieved through evaluating the following three objectives:

Objective 1: Evaluating the current defects in the risk assessment as a method used in the safety engineering system.

Objective 2: Examining top risk factors in UAE oil and gas construction projects.

Objective 3: Developing a framework to enhance the application of risk assessment for optimizing safety-engineering system.

Objective 4: Validating the developed framework through industry professionals feedback.

The goal of the first object is to expose the current issues that face the risk assessment in the oil and gas construction. This objective will help identify the different types of general concerns that may affect the performance and mechanism of the risk assessment implementation. This evaluation will cover all the possible affecting factors that come from different areas such as technical, procedural, and behavioral. For example, the technical side will be evaluated through assessing the below elements of risk evaluation process and approaches with respect to risk assessment implementation; risk identification, risk analysis, and risk control. In this part of evaluation, it is vital to evaluate the integrity of the risk assessment process where this evaluation would help determine and understand the efficiency level of the methods, either quantitative or qualitative, that are employed in each process in risk assessment and how control measures are applied. Additionally, the relationship between risk assessment elements will be examined to aid in forming a generic idea about the key mechanism of how hazards and risks are assessed and managed from the identification stage to the treatment stage. Furthermore, risk controls techniques such as engineering controls and administration controls will be examined. This will help identify the factors (whether technical or procedural) that are taken into account when selecting risks controls and how they affect the safe systems of work elements; materials, people equipment, and environment. This objective will help answer the following questions: what risk identification and analysis stages methods are used? What are the gaps in the risk assessment for oil construction? Moreover this objective will be evaluated through examining the five human factors listed below that affect the risk assessment implementation:

- Behavioral safety
- Educational and social barriers
- Organizational safety culture
- Employee welfare
- Leadership culture.

For the second objective, evaluating risk factors such as safety legislation, level of compliance, improper design, communication, budget, lack of resources, etc., can provide an integrated understanding and of risk assessment framework usage in UAE oil and gas construction. However, in this research work only the top risk factors will be examined to gain a specific scope of the major risk factors in oil and gas construction projects.

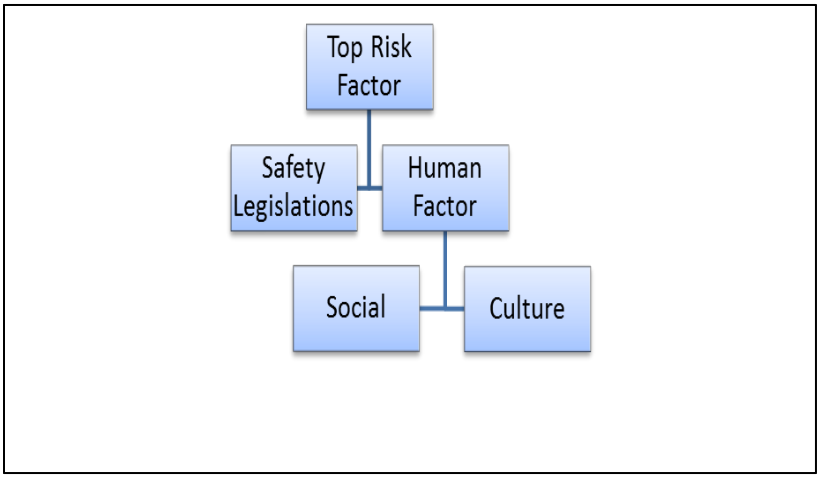


Figure 4: Top Risk Factors in UAE oil and gas construction projects.

According to El Sayegh, (2008), the significant risk factors in construction projects in UAE can be divided into two areas: safety legislations and human factors where both the owners and contractors have common risk factors during the construction activities. This research aims to cover these three areas from two perspectives: safety legislations and human factors as shown in Fig. 4.

Studying safety regulations and legislations result in a better understanding of risk assessment policy, features, and guidelines and that help identify any defects affecting the implementation mechanism from the legal aspect. Moreover, this research focuses more on risk assessment planning and monitoring. In this stage, it is important to see how risk assessment is involved in the business plan of the oil and gas construction companies. Equally important is to examine how these companies use their recourses towards risk assessment and what methods are used to monitor the safety performance, whether in the proactive or reactive stage. In addition this research strives to explore the mechanism of risk communication, and its accessibility, delivery methods and how this affects the implementation of risk assessment. This would help evaluate the importance of risk communication role in enforcing risk regulations in UAE oil and gas construction.

The last part in this objective is to examine risk acceptance criteria used in UAE oil and gas construction. Risk acceptance criteria strive to answer the question of how safe is safe enough, where as low as reasonably practicable (ALARP) principle is extensively used to decide whether to accept the risk or mitigate it. This usually occurs in the risk analysis step, aiding the understanding of how oil and gas construction companies are using acceptability and tolerability risk concepts in their acceptance criteria regulations and how financial factors (e.g. cost benefits analysis) can affect this process. Moreover in this objective, the research strives to identify and analyze the external and internal factors that affect the level of compliance towards regulations in the organization such as inadequate auditing and inspection, weak enforcement of local authorities and poor safety performance contractors.

1.7. Contribution to knowledge

The weakness in the implementation of safety system can be related to the inadequate risk assessment. The scenario of faulty implementation of risk assessment might be due to the organizational culture that affects the safety behavior of the employee. There are various scenarios and assumptions in theory but which ultimately fail in deciphering the real cause and effect of the implementation problem for oil and gas construction projects. Risk assessment implementation problem in the oil and gas industry can cause a lot of financial and human capitals loss internationally. Although the UAE oil and gas construction rigs have an improved safety performance system, UAE oil and gas construction rigs are facing risk assessment implementation problem like other oil countries in the world. To solve this issue, a specific and focused study should be carried out to identify the root causes. Many scholars try to analyze the implementation problem in the oil and gas industry and other heavy industries through different aspects, such as risk assessment, risk regulations, risk planning, and human error analysis. However, there is lack of integrated studies that evaluate the relationship between these elements and their effects on the risk assessment implementation in the Gulf area. Enhancing the risk assessment implementation will allow a better safety performance and culture in the UAE oil and gas construction rigs where human lives will be saved in addition to saving costs and adding monetary value to the oil and gas industry.

Studying behavioral safety and its role in risk assessment implementation is critical for the organizational safety performance as people are considered the most important resource for any organization. Most of the study that was conducted to determine the efficiency of the risk assessments focus only in the technical and procedural aspects without considering the behavioral feature. This research study will try to fill this gap by studying and analyzing the effects of technical, procedural and behavioral impact on the risk assessment method for all the employees in the organization. For instance, safety is not only meant for the end-user safety behavior at the operation stage, usually the scope is broader when senior management is involved. This will help determine the personal factors and the behavioral safety for all employees from management to end-user level. However, individual behavioral safety is directly affected by the cultural and educational factors. As such, this research aims to evaluate the educational level for the end-users and this will provide a general understanding an idea about the labourers awareness and knowledge towards safety. Nevertheless, determining the educational level is not enough for a full understanding of the individual behavior safety as the individual cultural safety should be examined alongside the educational level. Moreover, this research aims to evaluate organizational safety culture of oil and gas construction companies in the oil and gas construction rigs. Additionally, it strives to assess how organizational culture affects the safety behavior of the labourers in the construction stage. Moreover, employee welfare will be examined to observe how employees deal with mental and physical stress faced in their work place and how the management can demonstrate their leadership, commitment and visibility towards safety culture.

1.8. Summary of the chapter

One of the objectives of this study is to develop a framework for implementing risk assessment in UAE oil and gas construction rigs. The framework will cover three aspects: technical, procedural and behavioral. This framework will highlight the defects that influence the implementation of risk assessment in the oil and gas industry. The concept of this framework will rely on the results of the pervious objectives where it will consider the employees from the management to the operation level.

The framework will propose solutions and recommendations to fill the current gaps that affect the implementation of risk assessment in the safety management. This will also support King’s (1990) opinion that developing an updated safety framework from time to time in any critical industries would help learn from the previous mistakes, prepare for the current challenges and enhance the safety management performance for the future. The goal of this framework is to provide an integrated examination and suitable decision-making mechanism that leads to effective preparations and control methods for all the potential risks in different activities at the oil and gas construction industry in UAE.

Accidents and incidents can happen anytime during the construction process. Proper and adequate risk assessment can contain the number of accidents and may even remedy major HSE related problems. Without adequate risk assessment implementation, reactive accident response may be used rather than preventive planning. This may usually increase the cost related to response measures, delay the optimum response implementation and may even lead to expansion of the accident or the problem in hand. It is clear that, even if there is a good risk assessment and HSE performance in theory, there are some difficulties in the implementation which may cause unexpected accidents that affect all the safety business plans and the recovery process and may cost a lot of time and money for the company. Therefore, there is no guarantee for the improvement that is caused by risk assessment if there is no implementation.

Chapter 2: The current defects in the oil and gas construction projects risk assessment

2.1. Introduction

Safety engineering system is an integrated system in which all its processes are connected together in some way. According to Kaplan (1991), it can be agreed that risk assessment is the most vital in the safety engineering system process where the decision-making step is usually related with the findings of the risk assessment. To clarify, the process sequence of risk assessment is to identify, assess the potential hazard, implement the controls, whether engineering controls or administration controls, and then apply the recovery plan. Therefore, risk assessment process can be divided into four main actions: identify, assess, control and recover where these actions are directly related and can be highly affected by external and internal factors (ISO, 2008). For example, in risk identification stage, if the collected information about the hazard is not accurate and enough, a faulty analysis may be conducted in the risk analysis stage resulting in a lack of implementation towards risk assessment (HSE, 2001). According to Aven & Vineem (2007), even with risk assessment development there are many potential accidents in the oil and gas industry due to the implementation problem that leads to an inadequate risk assessment. In order to reduce and control these likelihoods, risk assessment should be implemented in a professional manner. Many scholars believe that the inadequacy of risk assessment could be due to the deficiency in risk assessment process elements.

Risk and hazard identification is the first step in the risk assessment process that is used in the oil and gas industry to identify the possible hazards that may be associated with a certain job. Schroeder and Kaclson (2007) mention that risk identification is the most important step in the risk assessment process in the oil and gas sector, because adequate risk identification generally includes; lesson learned, current status of risk assessment methods and HSE plan. The main goal of risk and hazard identification is to expose all the hidden hazards and provide a first response or mitigation plan to control the potential risks. The importance of risk identification lies within the way of its implementation that affects the next process in risk assessment. This is due to the fact that risk identification findings represent the first inputs for the whole risk assessment process.

2.2. Evaluation of technical challenges and defects in the risk assessment

Reviews and analyses of the lesson learned, current status of risk assessment and HSE plan in the risk identification stage would help in obtaining a better risk breakdown structure and that will strengthen risk identification implementation. Risk categories that are used in the oil and gas industry are; technical support, procurement and materials, startup & operations, field execution & logistics and organization and communications (Kerzner, 2003).

Kerzner explains that the inadequate risk identification in these categories will lead to weakness in applying risk assessment in the construction stage. As such, many oil and gas construction companies make sure to conduct Task Risk assessment (TRA) for any coming project. In (TRA) mechanism, the hazards are identified for different phases of the project and preliminary prevention plans or control measures are provided accordingly which lead to more accurate implementation (Yong & Mannan, 2010). There are number of methods and approaches that used for risk identification other than the TRA such as HAZID, HAZOP, and etc, but according to Chapman (2001), any method is used for risk identification purposes should include 5 important steps to be effective and implementable. Chapman suggests that the effective risk and hazard identification process should include the following steps:

- Knowledge-acquisition

  In this step, the overall objectives for the project should be reviewed with respect to the project parameters such as cost, timeline and planning. Moreover, an integrated assessment and examination for the general hazards that threat the project should be identified and discussed.

- Selection of the representatives team

  Hidden hazard is one of the main threats that affect risk identification mechanism in implementing risk assessment goals. To avoid that, Chapman (2001) believes that the team who participate in the identification and assessment of the risks facing the project should have people from the core business such as construction people where this will help expose hazards that are hidden to the senior management and engineers working in the offices.

- Presentation of the project process

  Chapman says that it is necessary for risk identification members to go over the project process to increase their awareness about the project which will develop their ability to identify the hazards for each phase of the project.

- Identification

  According to Wideman (1986), the identification step is more like breakdown process where each has its own way and system for utilizing the identification concept. However, the author says that for each method there are limitations that may determine how suitable the method is in regard to a certain activity in the project. Therefore, it is important from the representative team to have full knowledge about the capabilities of the used risk identification.

- Encoding

  The aim of this step is to register the potential risks and classify them in a qualitative manner.

- Verification

  Verification is used to obtain the assessment acceptance from the representative team towards risks and their sources, and the likelihood of occurrence and impact.

  Risk identification is not only about answering the questions of when, where, why, and how, the risk may be identified, one needs to determine risk factors, risk probabilities, and providing preliminary risk response plan which would result in having a better implementation of risk identification in the field (Eskesen & Tengborg, 2004).

Moreover, ISO 17776, (2000), that is tailored for the Petroleum and natural gas industries, includes guidelines on tools and techniques for hazard identification and risk assessment, as well as the Center for Chemical Process Safety (CCPS, 1992), both recommend the following risk identification methodologies: Preliminary Hazard Analysis (PHA), Hazard and Operability Study (HAZOP), Hazard Identification check list (HAZID), Environmental Issues Identification (ENVID) and “what if” analysis.

According to Hubbard (2009), risk matrix is usually used in the risk identification stage in the oil and gas industry where it could take different input shape such as 3x3 table, 5x5 table, or even more where severity (consequence) and frequency (likelihood) are used as parameters to determine the level and intensity of the risk as shown in Fig. 5. According to the author that the implementation problem in risk identification occurs when the wrong estimation in the consequence or likelihood is made. However, Sharhriar et al., (2011) believes that the real risk assessment implementation problem starts in the risk analysis step due to the wrong application of the analysis process. He says that risk analysis is used in different methods and techniques; Frequency approach or Bayesian approach, but to ensure the implementation is taken place, two factors should be applied in an effective way; determine the current control plans and consequences of potential risks.

		A	B	C	D	E
		Negligible	Minor	Moderate	Significant	Severe
E	Very Likely	Low Med	Medium	Med Hi	High	High
D	Likely	Low	Low Med	Medium	Med Hi	High
C	Possible	Low	Low Med	Medium	Med Hi	Med Hi
B	Unlikely	Low	Low Med	Low Med	Medium	Med Hi
A	Very Unlikely	Low	Low	Low Med	Medium	Medium

Figure 5: A 5x5 Risk Matrix Table (What is Risk Matrix, n.d.).

Aven (2009) states that risk analysis is so critical towards implementation because it is usually associated with decision-making. It is clear that, risk analysis deals with the uncertainties, causes, and consequence of risk. The result of risk analysis is usually followed by decision-making action in stages of risk evaluation and risk treatment. The decision made can directly affect the whole process of Risk assessment including proper risk assessment implementation. For instance, after analyzing the risk, the following actions may be applied depending on the decision-making criteria in the risk treatment stage; accept, reduce, avoid, transfer.

As Sharhriar et al, (2011), say that the methodology of risk analysis can affect implementation process. For instance, risk is usually defined as expected value of probability and consequences where probability parameter can be defined in quantitative manners such as empirical or numerical equations, or it can be defined in qualitative manner depending on other data such as historical data or background information. However, this classical definition of risk analysis function cannot be that accurate due to uncertainties that are usually associated with occurrences of the risk and this may affect the implementation process of risk assessment. To avoid and reduce this negative impact in risk analysis, Ersdal and Aven, (2008) say in their research that, improvement of safety barriers and good quality controls lead directly to better communication and enhance the decision-making towards the implementation. Moreover, it is suggested to use (ALARP) principle to have better risk analysis decision with respect to safety and cost to have a logical implementation.

2.3. Evaluation of organizational defects in the risk assessment

However, many scholars believe that the main reason for risk assessment implementation issue is due to the weakness and gaps in risk legislation, in which risk assessment process needs to be controlled in a systematic way with respect to the roles and responsibilities of each involved party. For example, Johnson (2014) states that risk assessment is a process and performance based approach and it is highly attached to the safety regulation in the heavy industries. The author says that, by having an effective limitations and requirements in the risk regulation, enhanced standards would be legislated that leads to better safety practices in the industries. Moreover, Hale (2015) supports this idea, stating that safety regulation is a dynamic process that consists of the following steps: Plan-Do-Check-Act (PDCA) cycle and to have high quality of implementation towards risk assessment, two things should exist in the regulation; monitoring and management of change (flexibility).

Hale defines monitoring as a rule follower where it is more like an active procedure for the whole risk assessment process. In the risk assessment monitoring, the purpose of this stage is to know the status of the project of concern in terms of the safety performance. This can be measured through daily, weekly, monthly and annual risk reports, where all working capitals, availability of the resource, and financial projections should be mentioned alongside with compliance, violation and deviation of the current project. Burke et al., (2012) mention that the existing monitoring system in the oil and gas industry needs to be restructured due to the inadequacy level. The authors say that the self-reporting system has a lack of transparency which cause lack in implementation for the whole risk assessment. The author uses as example the oil spill accidents that frequently happen in Grand Bank Eastern Canada which affect the biodiversity life in there. This support the idea of Hale that weak monitoring can indicate existence of different issues such as inadequate behavioral safety, but the effective monitoring can point out the challenges that risk regulation is facing especially in the planning phase in the oil and gas industry. In addition, many scholars believe that auditing can be a good method for monitoring in oil construction. It is clear that the purpose of reviewing the audit system is to determine the level of compliance towards risk assessment regulations. According to Wang & Li (2011), audit is a very effective indicator for determining external and internal factors that affect risk regulation system. The author explains that audit is usually conducted against the whole system of the organization. It requires reviewing a lot of documents that contains different risk regulations. The authors add that audit findings can develop and improve regulations for risk assessment which will result in better implementation of safety performance in the organization. Moreover, according to Wu & Li (2006), auditing can be a very good monitoring for ensuring regulation compliance. For example, many contractors show full compliance for regulation prior awarding their contracts and during the early stage of construction, but after proceeding for a while with construction activities, the compliance towards the regulation decreases because of insufficient audit frequency and follow up.

However, other researchers believe that reporting is the key to overcome all the organizational deficiencies that may affect the risk assessment implementation. According to Bridges, (2012) Near Misses are the best indictors to evaluate the risk assessment implementation. Near Miss can be defined as an unplanned sequence of events that could have caused harm if conditions were different or is allowed to progress, but did not in this instance (Bridges, 2012). In the oil and gas industry, Near Misses should be investigated to help identify the root causes. This would assist the company in understanding the defects in their HSE system. Since Near Miss Incidents have common causes to affect work procedures, response to the root causes of the Near Miss will eliminate the root causes of the accident. This highlights the importance of the Near Miss investigation as it is vital in preventing accidents due to the fact that generally Near Misses share root causes with accidents.

Reporting Near Misses has a big role in reducing accidents and injuries in the petroleum sector. For example, in Canada during the 1980s, when Near Misses began to be reported in the petroleum sector, injures record plummeted by 80% in 1986, thereby reducing direct cost by three million US dollars (Borg, 2002). Risk assessment implementation can be examined by the

Near Misses. Borg (2002) mentions in his technical report that although reporting Near Misses reduced the number of injuries, the number of Near Misses increased very rapidly in the oil and gas industry in Canada between 1980 and 1990 as shown in the Fig. 6. Naturally, since the number of Near Misses increased, the number of injuries decreased in contrast. Referring to the increased number of near misses, it seems there is a problem in risk assessment implementation. According to Phimistret et al., (2003), near miss reports and investigation reports reveal the control level of the risk assessment process in the construction stage. They can also help identify the root causes of the events and highlight the current and future challenges for risk assessment in the organization. By analyzing the type of near misses, one can gain a deeper understanding of the gaps in risk assessment implementation and remedy them. At the same time, even the absence of visible injuries does not necessarily indicate there being no issues in the risk assessment implementation. On the contrary, near misses may provide a better understanding of risk assessment implementation issues since they follow the same causation route of the injury.

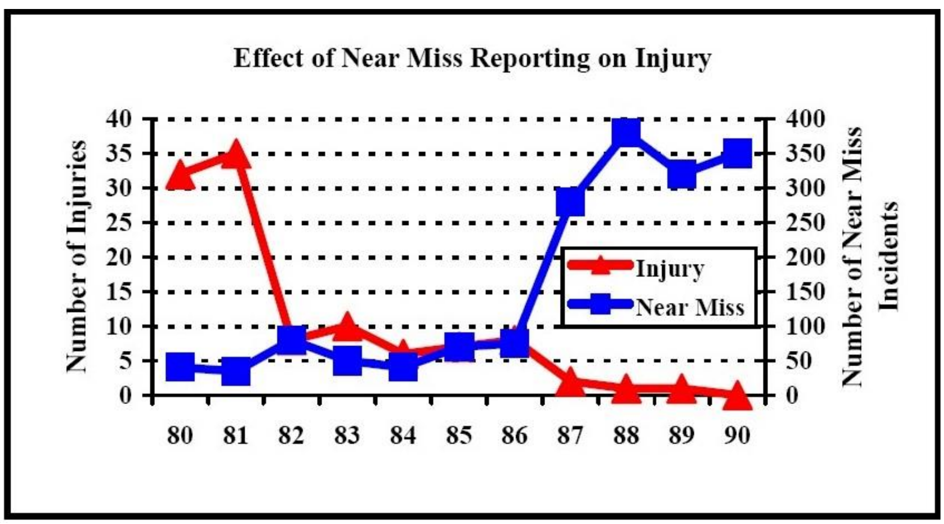


Figure 6: Number of accident vs. Number of Near Miss (Borg, 2002).

Gaps in risk assessment implementation at oil and gas construction rigs may lead to accidents during construction period. Even if the internal risk assessment process is strong, external factors may increase the risk estimation for a particular activity. There are different sources that initiate gaps in risk assessment, such as service providing companies, outsourced contractors, stakeholders, owners and etc. Thus, the value of the risk itself is uncertain and can be magnified according to the quality of the HSE system in place and other externalities that exist at the oil and gas construction rigs. According to HE Guixia (2011), one of the most important aspects in the oil production business that causes weakness in the HSE plan is difficulties in implementing the risk assessment safety measures of the HSE plan at the oil and gas construction rigs.

For planning Ramsay (1999) believes that there are many difficulties that affect the risk planning implementation in the organization business plan. It is clear that more resources are needed to control the risks listed, especially in the risk business plan. Any deficiency in these elements may potentially lead to implementation issues with the risk planning. However, Ramsay believes that proper training is the key to ensure the success for the risk planning, especially in cases of emergency. The author holds that in case of emergency, the proper and fast response is a vital element, highlighting the importance of the efficient training. To ensure that the employees attain the necessary training to handle the emergency case, the emergency plan should have the flexibility to be updated at all times with respect to internal resource of the company. Moreover, Ramsay says that communication between all the required parties during the emergency is an essential element in which failing in the risk communication could have dire consequences. For example, in high-level emergency case where a third party is involved with the owner and contractor companies to control the accident, such as blowout or fire explosion, risk communication becomes crucial in the contingency plan. This shows the important role of risk communication in implementing the risk assessment regulations. According to the Health and Safety Executive report (HSE, 2010), risk communication has a major role in implementing risk regulation, considering it the core of risk assessment process.

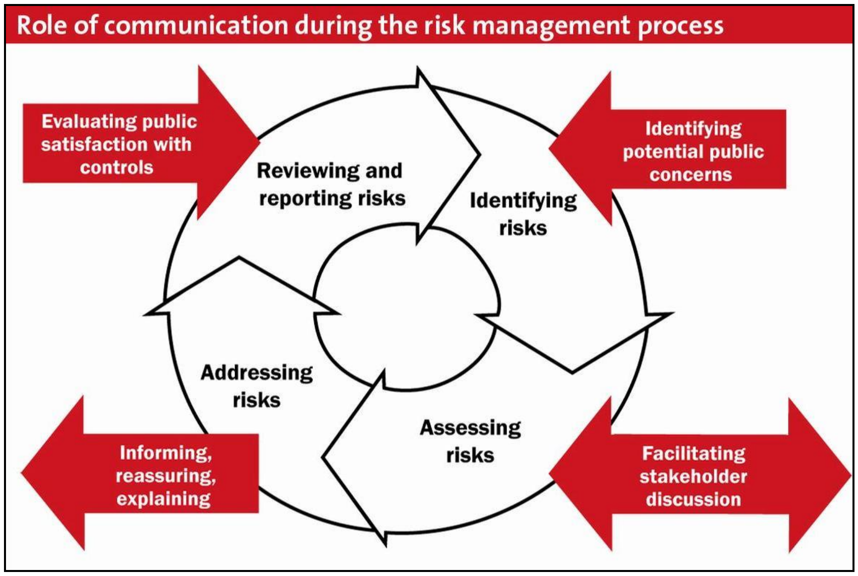


Figure 7: Role of Risk communication (Risk & Resilience, n.d.).

Fig. 7 displays how risk communication can ensure the stability and quality of Risk assessment process. It also has a critical role in the accurate implementation of risk assessment (HSE, 2010). Lofstedt (2008) states that in order to have a well-organized risk communication implementation in the company, integration between regulations and communication should exist. For example, it is important to provide vital and known communication channels for the employees to help them in knowing who to talk with and how to involve during accidents or crises. As such, it is important to regulate the roles of each party as this would help implementing risk communication in an effective way. In addition, Lofstedt believes that the main two challenges in risk communication are competence and capacity. For the competence element, the author says that risk communication is a very complex, dynamic process and to ensure its competence, it needs to be delivered in a limpid way that would increase the public awareness at the organizations. However, Dozier and Broom (1995) believe that the best way to enhance risk communication is to treat it as a process in the regulation. It is clear that the relationship between communication and regulations may take several forms. It is most effective when communication functions cooperatively as part of the regulations formation process.

According to Aven and Vineem (2005), even though there is good monitoring, planning, analyzing, and communication in the risk regulations, that does not mean effective risk assessment will be achieved if the risk acceptance criteria is not properly implemented. It is clear that the initial risk regulations focus on the risk analysis stages which provide the basic elements for decision-making with respect to choice of solutions and risk reducing measures. The latter two elements depend on the risk acceptance criteria. Therefore, any mistake in the risk acceptance such as accepting too much risk without enough resources to control it, would directly affect the outcomes of the risk analysis thereby affecting the whole implementation of the risk assessment process. For example, in the UK system, the installation cannot be operated until the authorities have accepted the safety plan, where the principle of as low as reasonably practicable (ALARP) is one of the main elements in the safety plan (HSE, 1992). Moreover, both Aven and Vineem (2005) believe that the first step to have an efficient implementation is to do quantitative pre-determined risk acceptance criteria. The authors agree on an evaluated balance between environment, economy, and human when using the ALARP principle in risk acceptance criteria especially in the oil and gas industry. Aven and Vineem (2005) hold that the main challenge towards risk acceptance criteria implementation is the uneven balance favoring economic benefits and cost savings on the account of the environment and human. As such Health and Safety Executive (2001) suggests employing triangle framework of acceptance criteria in evaluating risk a shown in Fig. 8.

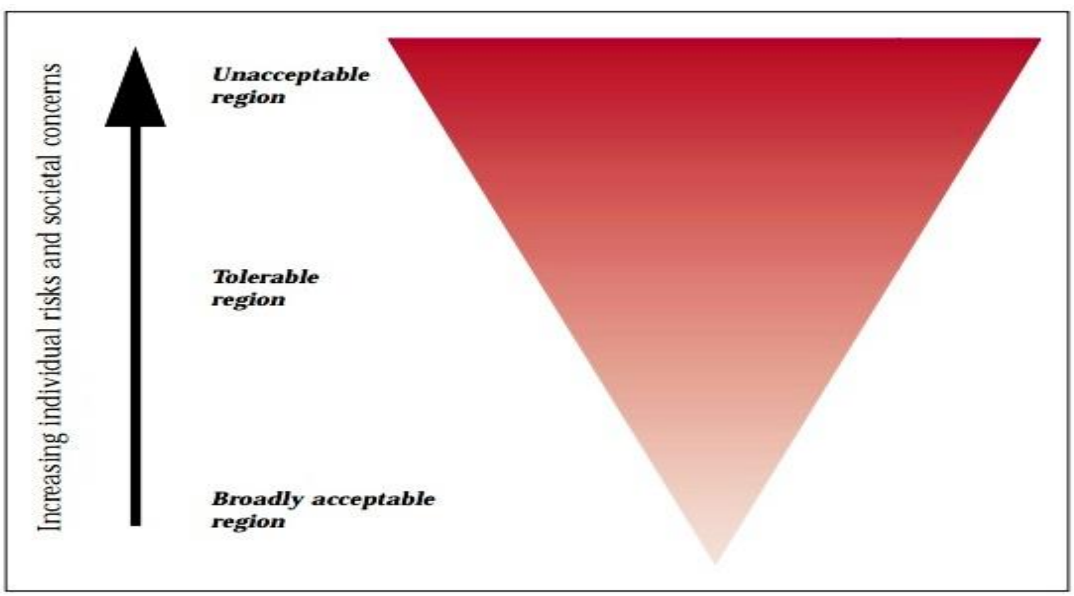


Figure 8: Framework for tolerability of risk (HSE, 2001).

2.4. Evaluation of behavioral challenges and defects in the risk assessment

Gordon (1996) believes that while technical and organizational factors can have a major impact on the safety and risk assessment in the oil and gas industry, personal factor have an even greater impact on influencing safety and risk assessment. This is due to the fact that the human factor is the main medium of interaction with other operating factors such as technical and organizational factors.

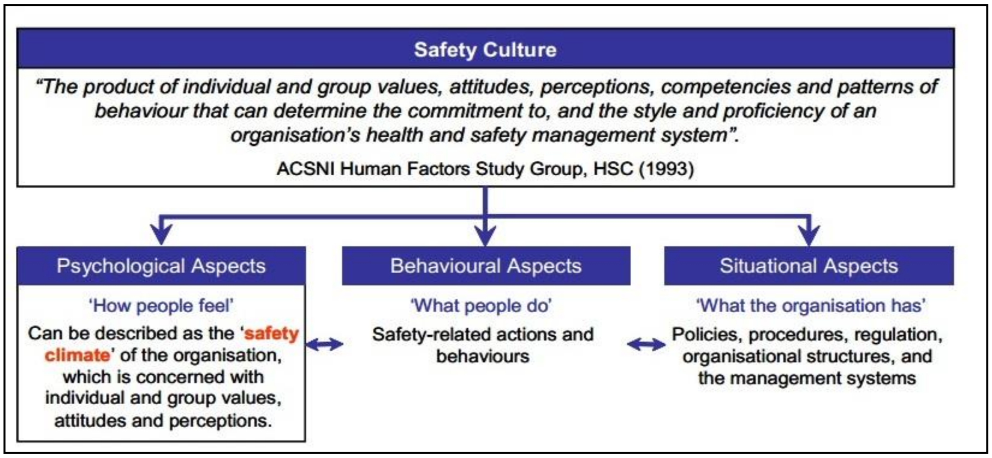


Figure 9: Safety Culture, based on Cooper 2000 (HSE, 2005).

The integrity of the human factors and their interaction will help ensure a better risk assessment implementation. French and Geller (2008) believe that in order to guarantee the stability of the human factors, it is necessary to create a safety culture in the organization itself. To carry this out management participation and encouragement is the key for implementing such culture as shown in Fig. 9. The authors claim that management should publish the safety culture between the employees through different activities such as regular inspection and auditing, awareness campaigns, training for competence assurance, positive promotion policy, and open communication.

According to Beatrice (2011), negative attitude displayed by management influence the organization's safety implementation, creating a blaming culture in the work environment. Beatrice mentions that management should promote a positive work culture. That is, they must accept employees as human instead of creating a blaming culture that may affect the trust and the openness of the relationship between the management and construction employees. This would create a blame-free culture that encourages employees to sustain good practices, such as reporting near misses, identifying hazards, and making recommendation. Gennard and Judge (2005), however, believe that even if the management wants to foster a free-blame culture, the change should start from the individual level. To do so, challenges and barriers should be examined as most barriers arise from Behavioral Based Safety (BBS) such as educational barriers. Deming (1993), who is considered one of the pioneers in safety engineering, believes that labourers with poor education usually do not prioritize safety which leads to productivity pressure from their seniors. Deming suggests that besides the proper training to maintain the competence level, labourers should be educated about the principle methods and implementation strategies of safety in the construction stage. This would grant labourers with a full spectrum of the importance of safety performance in their construction duties, which would in turn help them transition from knowledge based behavior to skill based behavior.

Moreover, according to HSE (2005), sufficient employee welfare is one of the main barriers that may face the employee in practicing positive BBS. It is clear that the employees need to work in safe and healthy environment that would help them to perform in a free-stress atmosphere and this will lead them to be more focused and morale on their job with respect to the safety matters as shown in Fig. 10.

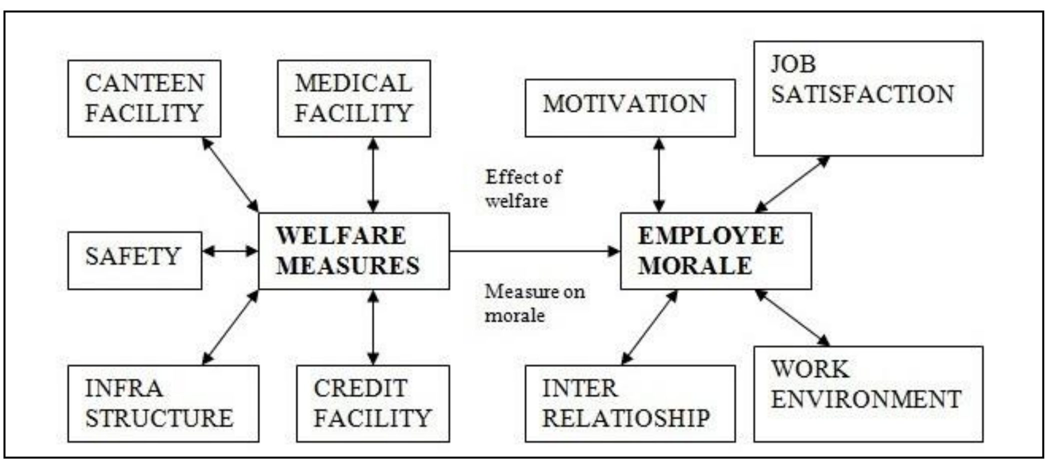


Figure 10: Effect of employee welfare (Maheswari, 2007).

HSE (2005), suggests that the first step to impose employee welfare in the organization is to establish welfare legislation which would enforce legally all activities and facilities towards employee welfare. For example in 1992, HSE established workplace (Health, Safety and

Welfare, 1992) regulations that concern the employee welfare in the working environment. The main goal of these regulations is to enforce the employers to provide safe and healthy services for the employee in their work place. Carrilo, (2010), says that providing a positive welfare services for the employee would lead to social, safety and economic benefits. For example, when positive and effective welfare is implemented in the organization, the employees would feel peace and equality in their job which would create healthy social relationship and satisfaction feeling between the employees. Due to this, safety attitude would be present in work environment that will enhance the organization productivity.

However, According to HSE, (2011), that it is really hard to maintain the safety behavior in the oil and gas industry without effective safety leadership. It is clear that, senior management should always have informed involvement role towards all the potential hazards that associate with the construction stage where they should fully aware about the safety measure that are practiced in the field. According to Eid et al., (2012), promoting safety leadership can has an effective role in implementing risk assessment as shown in Fig. 11.

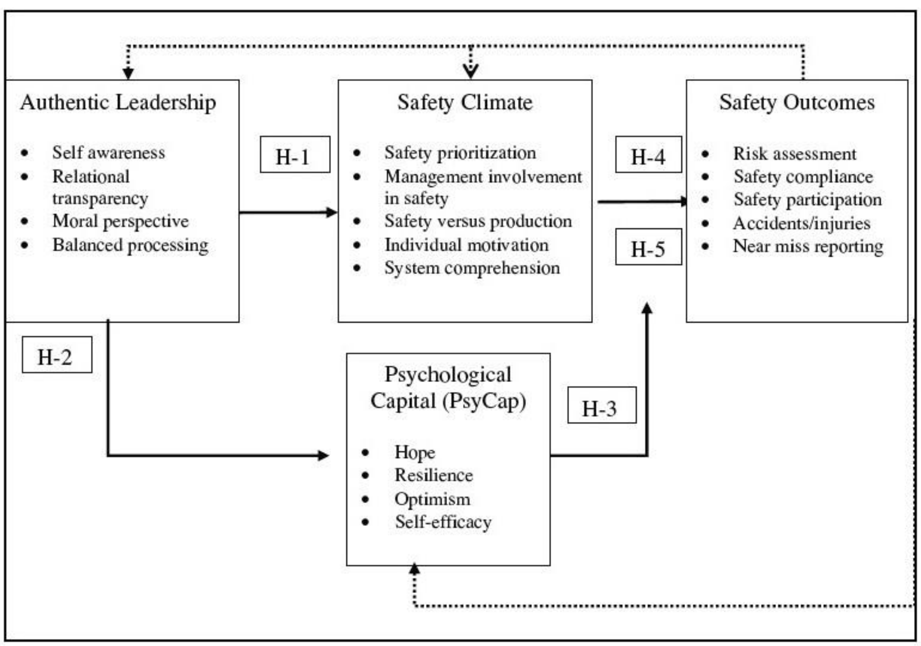


Figure 11: Safety leadership effects (Eid et al., 2012).

Eid et al., hold that in the oil and gas industry, to improve the risk assessment implementation, the management should provide the labourers with the necessary knowledge and training that would develop their hazard identification skills in the construction stage. This shows how visible leadership can promote healthy and safety climate between the employees. Wu et al., (2007) echoes the idea that effective management leadership can enhance the implementation of risk assessment because it improves the safety performance in all of its aspects i.e. technical, organizational and behavioral. According to the authors, to ensure this positive mechanism of leadership, there should be an open communication between labourers and management that will build trust between them. However, Clark & Ward (2006) point out that leadership management may face challenges from the construction due to negative peer pressure of the labourers towards safety implementation. From example, employees who got used to practice their jobs without full safety performance may resist and ignore the new safety orders from management which may send the wrong message to the management that the current safety situation is already in a good shape. The authors believe that to avoid this issue, it is recommended to involve construction employees more in the senior management meeting to have better understanding of the safety importance.

2.5. Evaluation of safety regulations, standards and agencies of oil and gas construction projects

2.5.1. Benchmarking approach

Many scholars in their research and studies believe that safety regulations and legislations can play major role in the risk assessment implementation. The importance of the safety regulations and legislations lies within their vital components such planning, monitoring, acceptance criteria, and communication. Ensuring high level of integration between these components is very essential for the implementation mechanism where it helps to have clear definition for the required roles and responsibilities in the risk assessment process. The importance of the safety regulations and legislations in oil construction industry increased gradually after several disasters and fatal accidents such as Piper Alpha in 1988. It is clear that more, safety case approach have been developed after Piper Alpha incident which contains moderate standards to ensure the (PTW) that was adopted later by the European Parliament (EP, 2013). As such it is critical in understanding the necessary of setting the proper and efficient legislations which can outline and describe the safety enforcement measures in the oil industry. For example, The Norwegian safety authorities such as Petroleum Safety Authority Norway

(PSA), Norwegian Environment Agency (NEA), and Norwegian Directorate of Health (NDH) have established safety internal control system that allow monitoring the safety performance for different industrial sectors including oil and gas sector (Chourdakil, 2012). This system has certain standards that are based on target setting legislations and can provide fundamental requirements and procedures of oil operations. This chapter will evaluate the status of safety regulations and legislations of oil industry in UAE and how it affects the efficiency of risk assessment implementation. This would be approached by analyzing and examining the current regulations elements and safety agenesis in UAE. Then a comparison exercise will be conducted through a benchmarking process with other regulations that are used in oil and gas production countries such as the UK.

According to Fabbri & Contini (2009), benchmarking is a vital method to evaluate risk assessment from regulatory perspective. The authors explain that benchmarking can be very effective for risk assessment regulations because it mainly assesses the difference between the organization and world class performances. Moreover, the authors believe that benchmarking can be considered as one of the continuous improvement techniques in risk assessment regulations where it tries to increase the organization knowledge that will help in improving their current processes and procedures. As result, the organization will start to follow the best practices that are used for risk assessment regulations in the world. In this study, the criteria of risk assessment benchmarking will focus on the following elements:

A. Acts and Safety authorities' regulations
B. Working Scope

Fabbri & Contini believe these elements to have a direct impact upon the regulations function in regard to the implementation of risk assessment. The benchmarking in this study will reflect on the current best practices for risk assessment in the oil and gas industry which are used by international oil and gas construction companies, international safety agencies, and international codes of risk assessment.

In addition the benchmarking will cover the relationship between oil and gas construction companies and safety governmental bodies. According to May (2007), the main goal of the government bodies is to provide regulations that ensure performing safely in industrial organizations. The author holds that when the government bodies provide a systematic approach through the regulations of industrial organizations, they expect that their performance would be based on these regulations. As such, industrial companies have a legal accountability towards these safety legislations and they need to fulfill their requirement in their construction. The authors believe that to ensure the implementation of the regulations, the safety government agencies need to follow up on the compliance of the industrial companies through different activities, such as auditing, inspection, annual reports review and meetings.

In this study, the relationship between the safety government agencies and oil and gas construction companies in UAE will be examined to determine how the risk assessment regulations for these oil and gas construction companies are related and can be affected by the safety government legislations. For example in Abu Dhabi Occupational Safety and Health Center (OSHAD) is the one who provides for different industrial organizations, including oil and gas industry, with the EHS management system and risk assessment regulatory framework that are required in each industrial sector. This research will focus on how safety government agencies monitoring methods are implemented for risk assessment regulations in the oil and gas construction companies. This would help understand the regulations enforcement, interaction, and mechanism for risk assessment between the safety agencies and the oil and gas construction companies in UAE.

2.5.2. Background to the oil and gas construction projects safety regulations

It is unfortunate that many regulations in the oil and gas construction projects have only developed after major disasters. For example, Craweley (1999) mentions that the regulations for oil and gas in the UK can be divided into two eras: before and after the Piper Alpha accident in 1988. According to the author, prior to the Piper Alpha incident, the regulations in UK were imposed more on the technical side which led to the increased use of the reactive approaches in the operation fields. Due to the huge economic losses of this disaster, the UK government pushed for improved safety legislations that were based on quantified risk assessment. This helped to have a broader perspective on the performance criteria of safety regulations where it contains the following advanced features:

- Fire and explosive protection, (HSE, 1997):

  Prevention of Fire Explosions and Emergency Response (PFEER) Regulations were established in 1995 by HSE to provide passive fire protection for oil rig installations in the construction sites. PFEER contains 25 regulations that contain approved practices for preventive and protective measures for fire and explosion hazards and efficient emergency plan.

- Environmental protection (OSPRAG, 2011):

  According to Oil Spill Prevention and Response Advisory Group (OSPRAG, 2011), environmental impact received its appropriate weight and proper attention after serious oil and chemical spills during construction projects in oil industry. To ensure regulatory control in the oil construction project, environmental agencies were formed such as (OSPAG) and Department of Energy and Climate Change (DECC) in United Kingdom Continental Shelf (UKCS) where they monitor the oil and gas construction companies activities through environmental studies like Environmental Impact Assessment (EIA) and Environmental statement (ES).

- Emergency escape plans:

  According to Furland (1992), failure in the emergency response in many accidents at oil construction industry was the main reason these accidents turned into disasters as the absence of visible and implemented emergency regulations and management can be the major factor. The author believes that many oil production countries start being aware of the critical role of effective emergency response to mitigate the severity of the risk that is associated with potential hazards in the construction sites. As a result, safety emergency agencies were founded such as UK National Contingency Plan (NCP) to endorse the important elements of the emergency response: planning, communication, training, and exercising for any coming oil construction project. This has led to having new safety practices in the oil industry as emergency risk modeling that needs to be evaluated by approved safety authority.

- Allocation of resource

  The concept of risk based resource allocation started rising in oil construction industry as part of control and mitigation strategies in risk assessment process. It had helped to have adequate estimation and preparation for different risks in the construction sites (Oyewole et al., 2010). The regulatory authority part in resource allocation is to guarantee its present in the oil and gas construction companies business and strategic plans. It is clear that the expansion of oil construction activities should go parallel with safety capacities and man power to mitigate injuries that may occur due to the increased workload. In addition, the author believes that safety allocation of resource activities such as equipment regular checkup can help in ensuring integrity of asset which leads to conducting risk assessment in a more efficient approach.

- Design and architecture

  Furland (1992) believes that safety regulations have moved from proactive to reactive approach and that is the reason behind increasing the importance of safety design phase. It is clear that, in the Piper Alpha accident, the design of the platform did not provide the crew members with sufficient escape routes that support the evacuation plan. Moreover, design can play a critical role in oil rig installation in the construction site. For example, safety design can provide a passive protection against fire through distributing the temperature profiles and heat flux on construction plant especially at the steel structure members. Moreover, safety designs can optimize sustainability trend in oil construction site by using construction materials that produce small amount of carbon monoxide in the manufacturing stage (ISO, 2008).

2.5.3. Safety regulations, standards and agencies in the UK

A. Safety authority regulations

Health and Safety at Work Act (HSWA, 1974) is the first safety authority that regulates the safety legislation for oil and gas construction activities in UK. The main goal of establishing this safety authority was to distinguish safety regulations from economic regulations. The safety legislation for oil and gas construction includes offshore, onshore and pipelines activities and while there is a separate legislation for each of these activities, they were all directed by HSWA. HSWA requires the duty holders in oil construction to demonstrate safety implementation towards HSWA risk based regulatory processes through clear safety management perspective. This leads oil and gas construction companies to use the ALARP concept in their risk acceptance criteria to tolerate all different risks that they may face during operation. As such, according to HSWA regulations, safety case needs to be submitted before the construction project commissioning phase.

In 1974, in order to ensure the proper implementation of the safety compliance, HSWA created an enforcement body called The Health and Safety Executive (HSE) that played an advisory role to support different construction industries in UK. For example, HSE provides the required training, publications and seminars to ensure the safety competence of the asset and workers at the construction field.

However, after the historical Piper Alpha incident in 1988, as a corrective response to enhance the organizational safety framework in UK, another primary safety act was established, known as The Offshore Safety Act 1992. The main purpose of establishing The Offshore Safety Act 1992 was to endorse and ensure the safety legislation of HSWA in the offshore oil and gas construction projects through reviewing the proposed safety cases.

It is clear that these safety cases should contain details as to how hazards and risks can be controlled, mitigated and reduced to follow ALARP principle through the company safety management at the construction stage. Later on, in 2005, HSWA was replaced by another regulatory body called the Safety Case Regulation (SCR). SCR was established from Offshore Safety Act 1992 as the main safety authority reasonable for the safety cases of oil and gas construction projects.

The following points summarize the generic roles description of HSWA and Safety Act 1992:

- Providing safe environment at the work place
- Defining the role of Health and Safety Executive (HSE)
- Approving safety cases for the duty holder
- Approving code of practices ACOP from HSE
- Investigating Accident and incidents through HSE

B. Working Scope

All oil and gas construction activities documents should be verified and reviewed by HSE with respect to Acts' legislations for projects in offshore rigs, onshore rigs, and pipelines where in each type of these projects, there is a specific regulatory authority which is reasonable of the documentation process with HSE, as shown in Fig. 12.

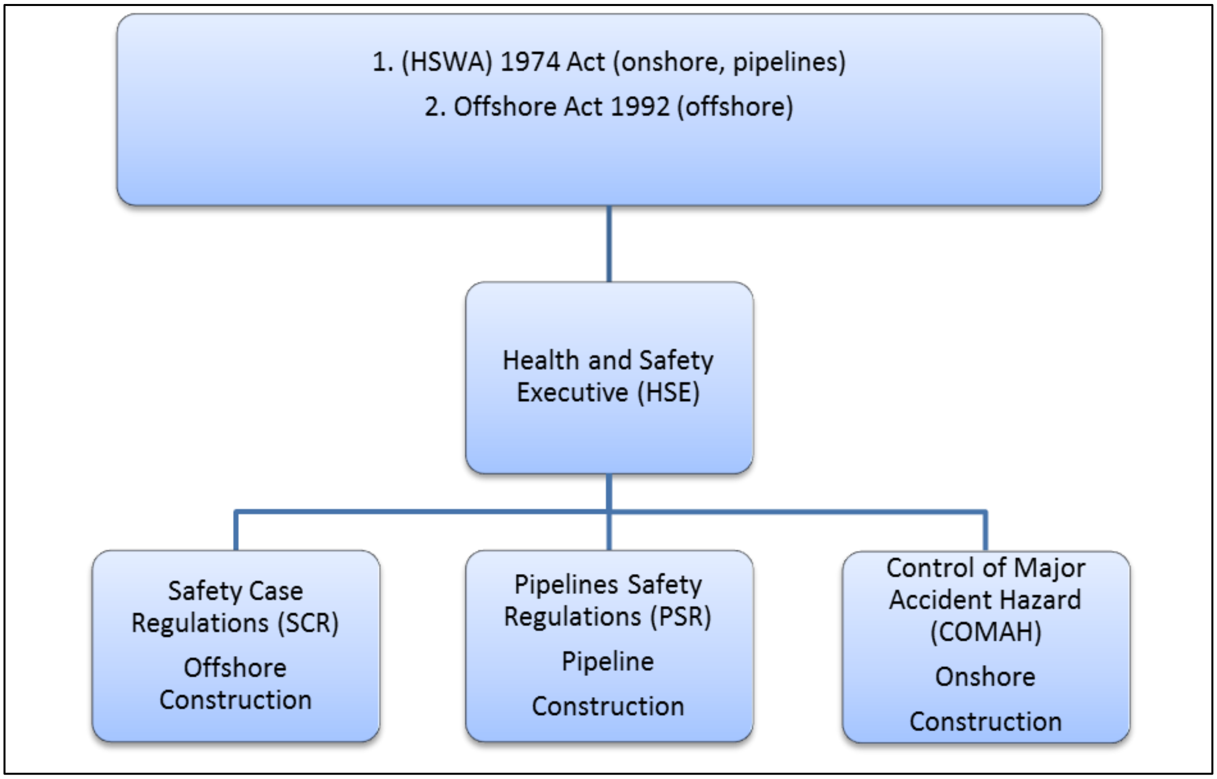


Figure 12: Safety legislative structure for oil and gas construction projects (Parliament, UK, 2006).

Safety Case Regulation (SCR) aim to reduce all major risks that can occur in the proposed offshore hydrocarbon construction projects from the construction phase to the operation phase. The duty holder needs to use an effective and clear risk assessment in each stage to identify all possible hazards and presents mitigation plans with respect to ALARP concept. There are specific requirements that the duty holder should provide in his/her risk assessment such as description of the used construction materials, the safety system during materials fabrication and installation, and safety maintenance plan for the next 5 years. These requirements of risk assessment should be detailed and explained in the whole construction project documentation lifecycle that starts in Front-End Engineering Design (FEED) in design stage to the well operation procedures stage.

For the pipeline construction, the main authority regulation is Pipeline Safety Regulations (PSR) where all oil and gas construction companies, whether onshore or offshore, should be complied with PSR standards to receive authorization permits before starting the job. This can be approached when the construction company submits a Major Accident Prevention Document (MAPD) that contains the mechanism of risk identification, risk evaluation, safety management and regular maintenance schedule in all construction project phases to PSR. Then, PSR reviews the submitted MAPD and provides recommendation for improvement in technical or procedural requirements. For instance, the risk assessment methodology in MAPD must consider the following elements: pipeline routing, human factors, mechanical properties of the pipeline and safety design factor. In addition, if the pipeline construction project may cause environmental damages to the surrounding area, the duty holder needs to submit EIA with detailed risk assessment of all the environmental hazards and proposed mitigation plans.

All onshore petroleum construction companies should directly define their scope of work to Control of Major Accident Hazard (COMAH) Regulation by submitting a safety case. This safety case represents an agreement between all important parties in the construction project i.e. duty holder, consulting and contractor, along with a key scheme of all the hydrocarbon substances that pose a major hazard in the construction site. The safety case explains in details the chemical properties of the hydrocarbon substances that are highly used in onshore construction projects and the best safety practices that are needed to handle and store them in a safe manner. After the Buncefield explosion in 2005, the focus on the danger of hydrocarbon substances increased, prompting COMAH Regulation to require that all the duty holders have specific risk assessment for all the construction activities that are associated with the hydrocarbon substances and present the control measures (HSE, 2011).

2.5.4. Safety regulations, standards and agencies in the UAE

A. Safety authority regulations

There is no official separate government body or authority which monitors safety engineering matters for oil and gas construction projects in the UAE, on the federal or local level. However, all HSE principles are addressed through several main federal and local legislations without explaining the technical requirements that should be implemented (Butt, 2001). For example, the Federal Ministry of Labourers sets Law No.8 of 1980 that requires all employers in the oil and gas industry to ensure the safety of their employees at the workplace. For the environmental safety, the Federal Environment Agency, which was replaced by the Ministry of Environment and Water, established Law No. 24 of 1999 which requires assessing the environmental effects and developing environmental protection standards in any industrial project in the UAE.

Since UAE has federalism constitution, however, each Emirate has its own local regime for the oil and gas industry that regulates all the industry activities such as construction, production, and operation. There are three main Emirates that have petroleum activities as illustrated below in Fig. 13.

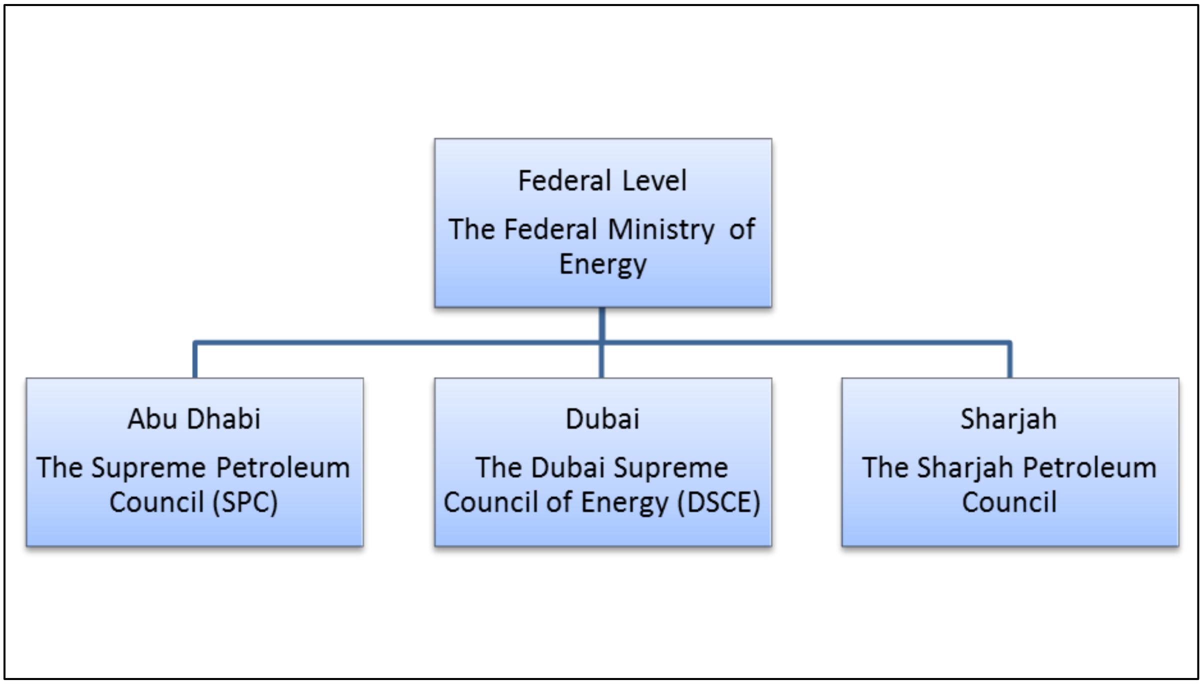


Figure 13 :legislative structure for oil and gas industry in UAE.

According to Johnson et al., (2005), Abu Dhabi produce around 94% of oil and gas in the UAE and as such construction industry is very active and plays a major role in enhancing the core business especially on the upstream chain. As shown in Fig. 13, Abu Dhabi National Oil Company (ADNOC) is responsible for ensuring the implementation of all Supreme Petroleum Council (SPC) regulations including the safety procedures for oil and gas construction projects. In Dubai, the legislations for oil and gas construction, operation and production projects, comes directly from Dubai Supreme Council of Energy (DSCE) where the department of petroleum affairs is in charge of all the administration works for these projects. The same regulatory system is practiced within Sharjah, particularly Sharjah Petroleum Council represents Sharjah government and has the authority to set the legislative structure that involves defining safety regulations of oil and gas industry projects.

B. Working Scope

The working scope differs from one emirate to another due to the federalism constitution. This part will focus on the work mechanism in Abu Dhabi since it holds more than 90% of oil and gas construction projects (Johnson et al., 2005). Most of the contactors companies need to submit their HSE performance profile during the tendering stage to the owner company such as Abu Dhabi Company for Onshore Oil Operations ADCO for onshore concession or Abu Dhabi Marine Operating Company (ADMA-OPCO) for offshore concession. Then, it is up to the owner company to decide which safety study the construction company needs to consider for the proposed projects. Each operational company has its own safety de-minimis system that is flexible to choose any format or methodology of the risk assessment for the proposed safety study. As previously mentioned, there is no specific federal or local authorization body to monitor or ensure the safety construction legislations implementation in Abu Dhabi; instead, the owner companies conduct frequent audits and inspections to construction sites and check the contractors' implementation of the safety legislations. From the results of these audits and inspections, an annual safety report will be generated and submitted to ADNOC to review and then to OSHAD for their record only. OSHAD plays only an advisory role for all safety engineering matters in oil and gas construction projects since it does not have full authority to act as a complete monitoring agency in the oil and gas industry. However, for other sectors, OSHAD ensures the HSE compliance in construction projects through auditing and inspecting since it is the Sector Regulatory Authorities (SRA) that is assigned from Abu Dhabi government for the construction HSE matters.

2.6. Evaluation of research and development on risk assessment frameworks

Due to these technical, procedural, and behavioral challenges towards risk assessment, many scholars strive to develop a variety of frameworks that may enhance the performance of the risk assessment mechanism to overcome these challenges. They try to integrate other factors beside the likelihood and the consequences of the hazards. For example, many scholars attempt to combine environmental impact (Slootweg et al., 2001), social impact (Goldman & Baum, 2000), and health impact (Rattle & Kwiatkowski, 2003) in the risk assessment to have wider and better identification and estimating for the potential risks. Renn and Walker (2008), believe that these framework can be very beneficial for risk assessment and it can enhance its performance against technical, procedural, and behavioral challenges if they involve the basic components of risk assessment. As established already, these are identification, assessment of exposure and estimation of the risk.

For example, Mahmoudi et al., (2013) have created a behavioral framework to develop the risk assessment by combining the social impact on the assessment methodology where they proposed five steps framework that include a hybrid model consisting of two main elements: risk and social. The authors believe that analyzing the social impact will provide a comprehensive diagnosis for socio-economic and socio-cultural concerns that employees can link to the hazards in the risk perception stage. In addition, the authors conclude that their framework can provide effective basic information to organize recovery programs that deals with natural disasters such as earthquakes and floods.

Many scholars developed several frameworks to enhance the risk assessment implementation and performance in the oil and gas industry. The studies in the literature review usually cover the issues in the implementation from one aspect or angle without analyzing the connection and the correlation between different types of hazards and how they can work as one effective unit. For example, Cox and Tait (1998) believe that many organizations in heavy industries have limited and lack of knowledge in risk assessment methods due to the absence of a comprehensive understanding of hazards and their contribution and interaction in the workplace. Chan (2011) conducted a study to identify the ranked critical accidents, root causes, and mitigation site plans and how the different perceptions of the risk between the organization and stakeholders affect the safety performance. In Chan's research, he found that the top ten ranked risks for the organizations and stakeholders are different, whereas in the survey the organization representatives believe that the technical aspects such as fire, explosion, and failure in equipment are the most dangerous risk types for the oil and gas industry.

The stakeholder's response, however, was different where they think that organizational and human factor obstacles such as inadequate standard procedures, poor communication and mental stress can lead to the critical accidents that result on serious injuries. According to the author, that these different perceptions between organizations and stakeholders reflect how risk can be complex multidimensional phenomenon in the oil and gas industry. As such the author suggests providing new perspectives on accident mitigation plans which include a mechanism that can break down the complexity of the risk in the oil and gas industry.

Other scholars developed certain frameworks to enhance the risk assessment and management process in the oil and gas industry from a technical aspect. For example, Aven et al., (2007) proposed a framework that focuses on the decision-making mechanism of the risk assessment and management process. The authors believe that many current risk assessment methods that are used in the oil and gas industry do not utilize the right procedural approach in classifying and characterizing the potential risks at the construction stage. The authors say that the process of pre-decision-making involves the usual risk analyses techniques, ALARP principle and cost-benefits analyses which do not provide enough illustration of risk and its uncertainties. As such, in their framework, the authors classify the decision-making into three categories with respect to the risk complexity:

1. Standard decision-making process
2. Advanced decision-making process
3. Complex decision-making process

In each of these categories, there is a specific methodology for risk assessment and management process where the controlling factors are uncertainty and manageability that usually shape the decision-making process for the wanted event. Fig. 14 displays the mechanism of the proposed framework.

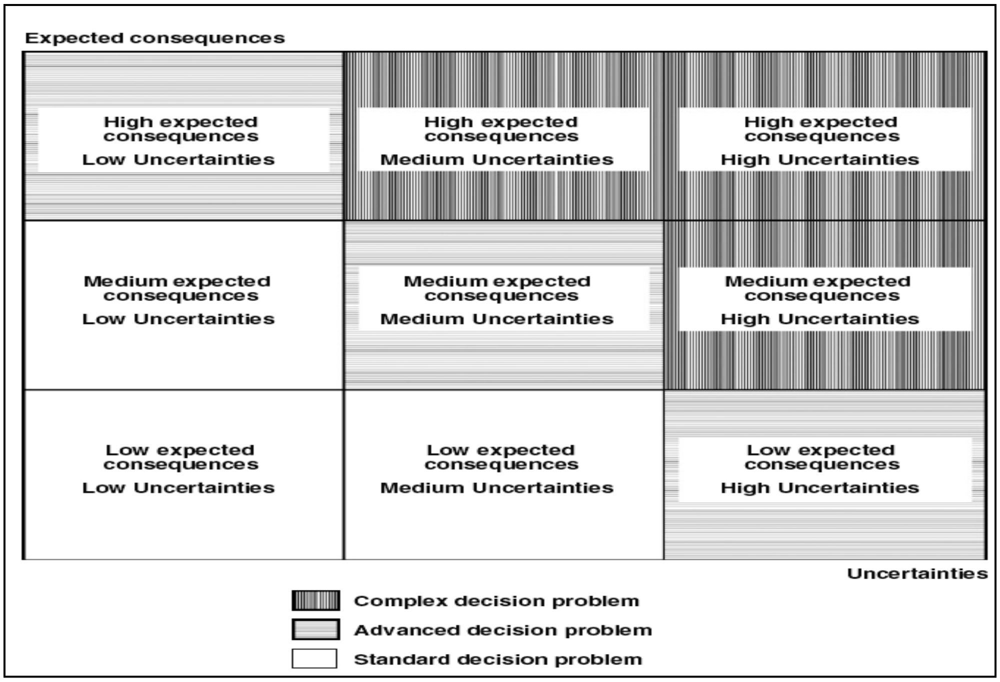


Figure 14: The structure of the suggested decision framework (Aven et al., 2007).

The authors recommend involving stakeholders in the risk based assessments in oil organization. According to the authors, this will provide an integrated awareness about the principles and strategies used for decision-making process in risk assessment.

Xu & Fan et al., (2014) proposed procedural framework to develop the risk assessment implementation in the oil and gas industry in China. According to the authors, natural gas wells in China are facing a serious technical problem due the high percentage of hydrogen sulphide (H_2S) in these wells. For example, in 2003 a fatal blowout occurred in Kaixian County of Chongqing city that resulted in the death of 243 people, prompting China safety engineers to review the probabilistic risk based assessment methods that are used in the oil and gas fields at the construction stage.

In this framework, Xu & Fan et al focus more in the fault tree development technique where their framework will implement the individual risk concept. It is clear that the authors and other scholars (Li et al., 2007) believe that there is lack of framework that utilize the individual risk assessment in their risk assessment process, which leads to weakening the level of the individual hazards identification. To apply this concept, the authors employ the free tree analysis to identify the uncertainties that are associated with the blowout accidents that resulted on the failure of safety system as shown in Fig. 15.

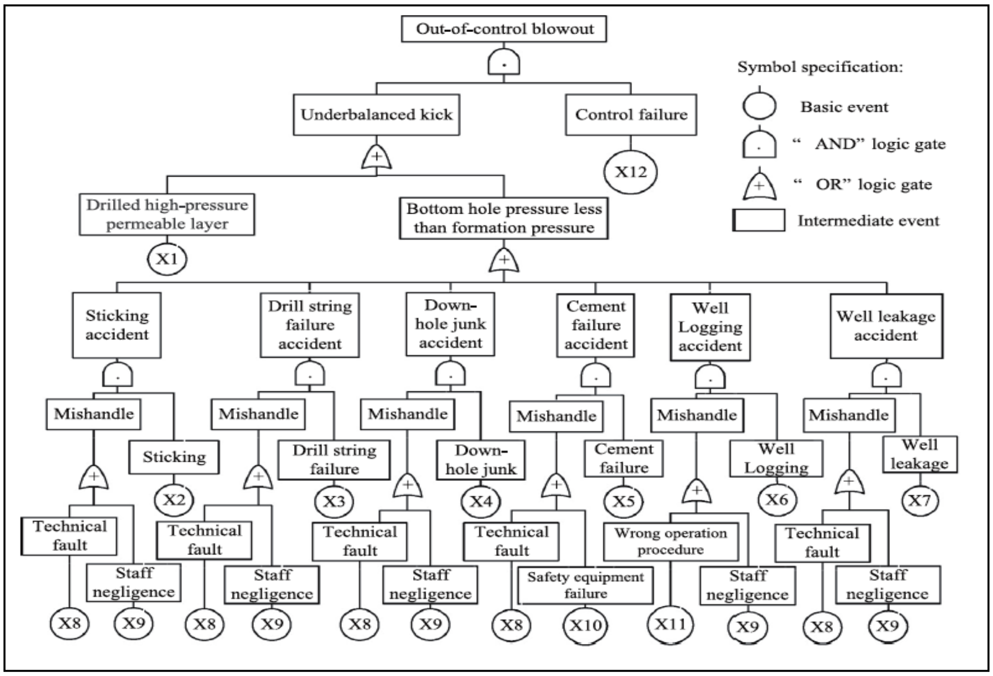


Figure 15: The proposed fault tree for well blow out control (Li et al., 2007).

To enforce the organizational aspect in the individual risk assessment process, the authors established the acceptable risk level of individual which provide the reference procedures to involve the safety mitigation measures in emergency and awareness planning zones and exploration stages. For example, this framework suggests calculating the death probability with respect to the individual in certain location during the H_2S diffusion that will have safer estimation for the toxic concentration. In the end of their paper, the authors mention that their framework can enhance the risk assessment for the development of high acid well through stage procedures that enforce the individual risk concept.

Besides frameworks proposed to enhance the efficiency of risk assessment in the oil and gas industry, scholars insist that behavioral issues are the main challenges of risk assessment process. For example, many researchers believe that psychosocial-behavioral risk can have a direct effect on the oil and gas fields employee that may lead to catastrophic accidents such as fire, explosion, blowout, and toxic release (Johnsen et al., 2010; Mearns and Hope, 2005; Nahrgang et al., 2011).

Bergh et al., (2014) developed a framework that contains and analyzes psychosocial risks in the oil and gas industry where this framework works as indicator to help in managing psychosocial risks and measure the performance. It is clear that, according to the authors, psychosocial risk assessment is important because it deals with behavioral hazards that occur in the design, organization, and construction phases and it will help improve HSE risk assessment performance in the organization. The authors believe that the psychosocial risk assessment needs to be linked to the organization strategies so that HSE performance indicators are developed, enhanced, and can be used to monitor the potential psychosocial issues that may affect the wellbeing of the employees.

The main goal of this study is to create Psychosocial Risk Indicator (PRI) that will provide a more integrated decision-making process in risk assessment mechanism. The methodology of this framework was conducted through a survey that contains several factors of psychosocial behavioral such as job control and relationship where in each factor there are number of questions as shown Fig. 16.

Factors (underlying dimensions)	Single items
Job control	Your possibility of knowing what tasks to prioritise The degree of influence concerning your work Your possibility to plan your own working day The degree of influence on the amount of work assigned to you Your possibility to be sufficiently involved in decisions that concern your work The degree of influence on what you do at work Your possibility to set your own work pace Your possibility to decide when to take breaks Your possibility to get help to prioritise the tasks The degree of influence over the way you work
Job demands	Your possibility of keeping up with tasks The level of your workload The level of your work intensity Amount of tasks compared to the resources available The congruence between your skills and the job to be performed Your capacity to deliver according to demands
Role clarity	The clarity of the areas of your responsibility The clarity of what is expected of you at work The clarity of planned goals and objectives for your job
Support	The support from your immediate superior The availability of your colleagues The availability of your immediate manager The support from your colleagues
Relationships	The quality of relationships in your entity The level of co-operation in your entity The level of communication in your entity

Figure 16: Psychosocial-behavioral risk survey (Bergh et al., 2014).

For each question in the survey, there is a categorized numerical answer attached to the question. In the end of the survey, one can calculate the score by adding up the numerical values generated for each answer and obtain the total score to identify the level of psychosocial behavioral as shown in Fig. 17.

Recommended PRI follow-up	***Cut-off score***
Green	≥ 73
Yellow	64 - 72
Red	≤ 63

Figure 17: PRI score system (Bergh et al., 2014).

According to the authors, the framework questions and scoring system is based on previous theories that utilized the psychosocial risks in work environment, business processes, and organizational structures in different heavy industries.

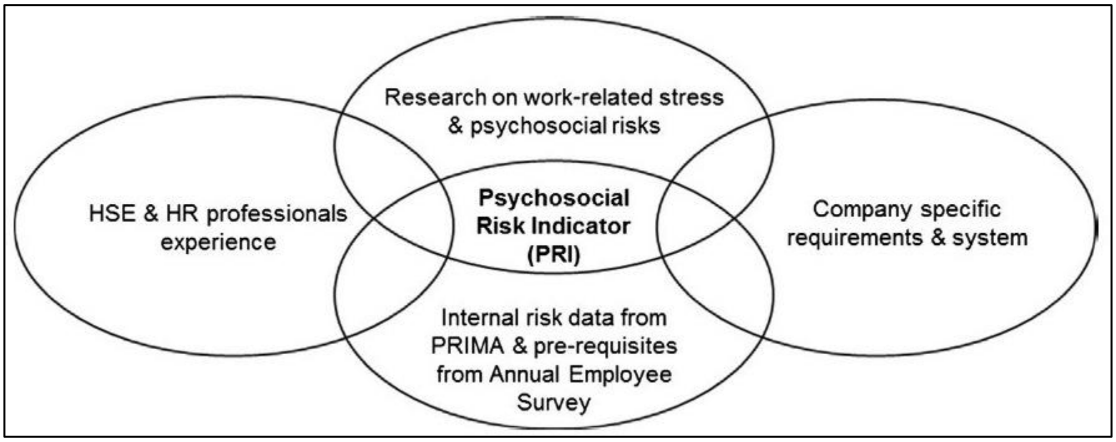


Figure 18: Source of Knowledge for PRI framework (Bergh et al., 2014).

These psychosocial theories cover four main areas, as shown in Fig. 18:

1. Scientific researches in psychosocial risks and stress in work
2. HSE experience
3. Internal data

4. Company regulations

The authors mention in the end of their paper that their framework proposed an indicator for psychosocial risks in the oil and gas industry. The framework is efficient because it allowed the risk assessment process to have a wider scope in behavioral safety concept. The psychosocial framework for risk assessment enhances the HSE performance of other KPIs and that will directly reflect on the advancement of the HSE management system indicators. Simultaneously, the framework will reduce human errors in the future. Furthermore, Bergh et al., (2014) highlight that having free psychosocial risk environment in the workplace will promote the social-sustainability relationship between the construction and the management employees. The limitation of the framework, as mentioned by the Bergh et al, is that the framework only indicates the psychosocial risks without tackling with the psychosocial risks themselves. The authors recommend establishing mitigation framework to control and better manage the psychosocial risk that may occur in the construction stage in the oil and gas industry.

2.7. Summary of the chapter

As examples were shown above, most of the frameworks are orientated into one aspect e.g. technical or procedural which leads to compromise in the other attributes. The absence of the integrated examination in the risk assessment frameworks impacts the required cohesiveness of safety system. In addition, vital details were not presented in several frameworks that ought to be mentioned as essential contributors of safety performance. A common example is, the equipment integrity and its maintenance recorders that exist in the construction site. As consequence, this study aims to develop a framework that has a comprehensive mechanism for the risk assessment that utilizes all the potential risks coming from variety sources in the construction site. This will help have a clear image for the possible hazards and what are the mitigation plans that should be conducted to manage and promote the best safety practices to control these hazards. This shows that the general methodology of developing this framework is clear, but, in this stage of the research, it is hard to specifically mention the parameters of the framework. This is because it relies on the results and outcomes of laws, regulations and human factors evaluations in the risk assessment that will be conducted as early objectives of this study. However, the decision-making process for this framework should include three main examination steps: technical, procedural, and behavioral that presents the integrity evaluation concept to enhance the safety and reliability implementation of the risk assessment in the oil construction in UAE, as shown in Fig. 19.

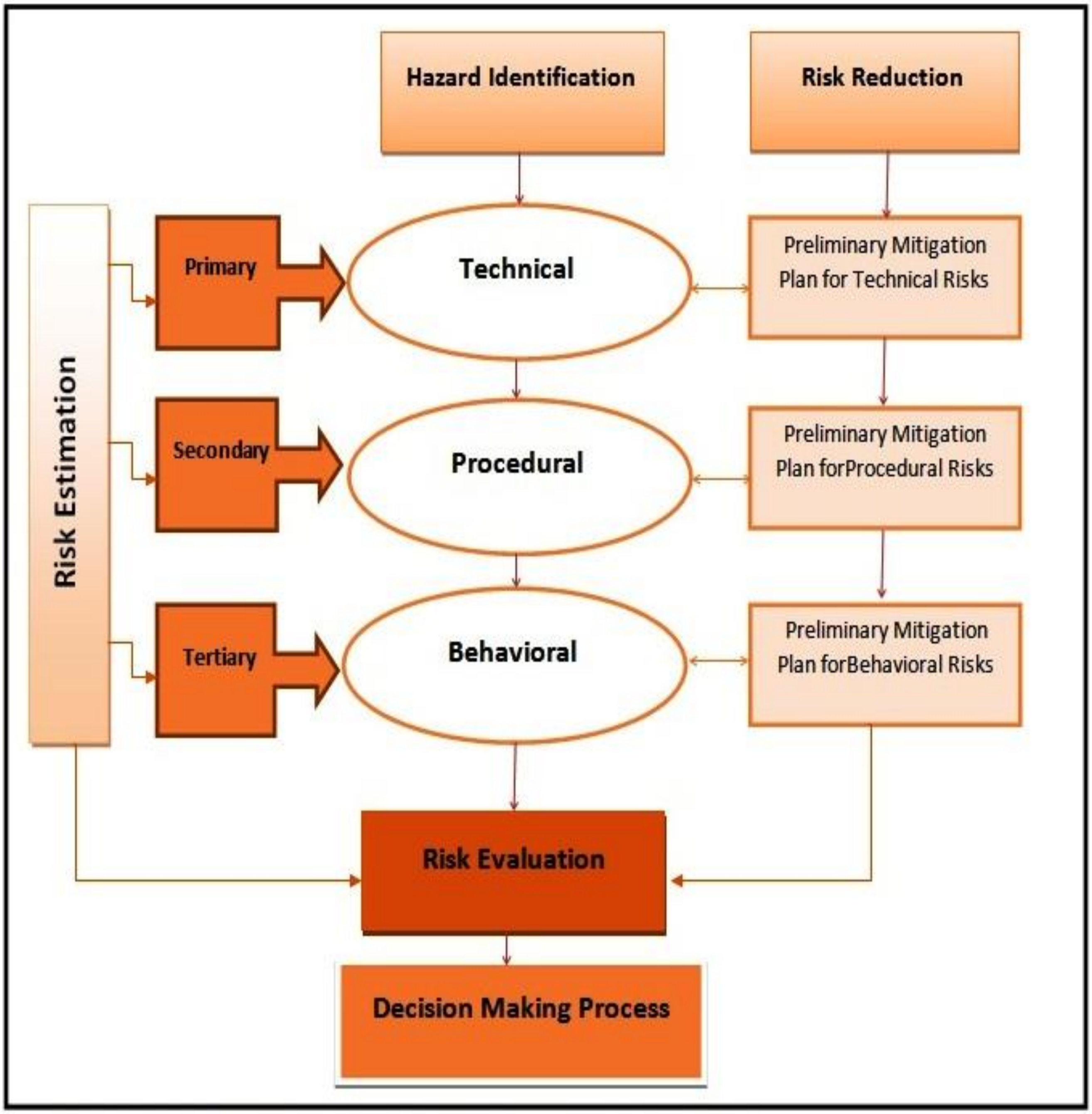


Figure 19: Conceptual Scheme for Tertiary Risk Assessment Framework.

Chapter 3: Research Methodology

3.1. Introduction

The aim of this study is to evaluate the implementation of safety engineering system in oil and gas construction through risk assessment in UAE. To do so, four objectives should be examined, where these objectives contain three different aspects; technical, procedural, and behavioral. Each objective has different methodology in order to be achieved in this research Andersen & Mostue (2012) conducted an experiment to evaluate risk analysis and risk assessment approaches that are applied in the petroleum industry in Norway. They used a survey to determine the risk analysis methods of different oil and gas construction companies in Norway and to expose the challenges in the risk assessment.

In this study, the similar approach will be employed and a survey will be utilized to determine the risk analysis and identification methods of the UAE oil and gas construction rigs, along with their weaknesses that affect the implementation of risk assessment. In addition this research will have combination of exploratory and descriptive methodology approaches. For example, in the exploratory feature, one of the questionnaire objectives is to explore the implementation problem to provide insights into and comprehension for more accurate examination. Furthermore, since this research covers the behavioral attributes of the individual worker in the construction site, a description of characteristics and functions is required which gives this study a descriptive trace in the methodology stage.

However, the focus in this survey will be on the following points to help identify the technical, procedural and behavioral defects in the risk assessment process, distributed to both management and construction people:

A) The risk based assessment

In this part of the survey an evaluation will be conducted towards the efficiency level and application of risk assessment that are implemented in the construction stage such as HAZOP, FTA, ETA, and EIA in oil construction.

B) The compliance level towards Risk assessment process

Reviewing the incidents and accidents history records that occurred in UAE onshore oil and gas construction rigs due to the inadequate risk assessment could be considered one of the effective ways to determine the level of compliance in risk assessment. According to Hopkins (2011), compliance to risk assessment is a vital indicator of the risk assessment performance. The author mentions that in hazardous industries, reviewing the compliance of risk assessment process through accidents records would help expose technical and procedural defects that have a direct impact on the decision-making mechanism.

C) The roles and responsibilities in the risk assessment

According to Heijden (2006), evaluating roles and responsibilities would help in forming an adequate implementation for risk assessment process in the organization. The author believes that the competence level of management can be evaluated easier when the roles and responsibilities are clearly defined, which help in applying any improvement to enhance performance mechanism when required in the risk assessment process. Moreover, Hillson (2004) claims that defined roles and responsibilities can promote positive authority in the risk assessment process. It is clear that the author believes that identifying the hierarchy of authority would ease the understanding of the assigned roles and responsibilities, which grants the organization an informed path towards risk assessment.

D) Risk controls

According to Khan et al. (2002), there are four important areas that control measures cover in risk assessment process: equipment, materials, environment, and access.

According to the authors, each company utilizes these external factors through different approaches thereby determining the effectiveness of control measure in risk assessment of the oil and gas industry. It is vital to evaluate the hierarchy of control measures that is used in the risk assessment process in the UAE onshore rigs. The hierarchy includes four important prevention measures: elimination, substitution, engineering control, personal control and personal protective equipment (PPE). To do so, it is critical to analyze the factors that may affect the company’s choices of control measures such as cost, applicability and effectiveness. This can be achieved by reviewing pervious case studies in which different corrective actions and control measures were employed to contain the risks. This would help understand the risk control mechanism in the risk assessment process and expose any defects that may occur in this revision of the case studies.

E) The safety culture in the organization

According to Odea & Flin, (2001), a questionnaire is an efficient method to collect data pertaining to human factors in the oil and gas industry because employees in this industry are highly familiar with questionnaires technique which allows them to respond in an efficient way and examine the safety culture in the organization. Both of the authors conducted a behavioral safety experiment through questionnaire to determine the safety leadership level between the managers in the offshore and onshore rigs in United Kingdom (UK) during the installation stage. The authors believe that the design of this questionnaire helps employees in exposing behavioral issues that simulate real cases between construction and management employees such as visibility, workforce involvement, and competency. In this research, this part of the questionnaire will focus more on the safety culture between the management and the end-users employees, and how it affects the safety performance implementation. For example, the survey will include questions about the level of safety leadership, along with its visibility and involvement from the top management to the labourers. The official safety practice and the supervision level for unsafe behavior acts in construction oil fields will be examined in this section of the survey.

Beatrice (2011) claims that it is vital to collect qualitative data on examining the role of human factor towards safety implementation. Questionnaire is a very effective way to conduct this examination because it helps the examiner to be closer to the employees' world and observe the challenges they face and those which affect the behavioral safety. For example, educational background and work pressure will be analyzed through the questionnaire. This will help identify the hidden human factors that influence the risk assessment.

Ismail and Hashim (2012) conducted an experiment to evaluate unsafe work processes, unsafe condition and the implementation of safety practice in the field for three oil and gas construction companies through BBS approach. In this approach the authors use personal questionnaire as methodology to collect qualitative data where the survey were held in the field and that helps the authors to have more information because it allows the examiner to collect and observe the information simultaneously. According to Sutton (2014) that (BBS) plays a major role in changing the safety engineering development landscape especially in the beginning of nineteen-nineties as shown in Fig. (20). Sutton explains that scholars and professionals in all heavy industries including construction in oil and gas sector, tried to enhance the safety procedural and technical phases through codes, standards, and regulation, but still major accident such as Chernobyl disaster in 1986 and Pipe Alpha in 1988 still occurring. Due to that safety experts start emphasizing on the safety behavior of the individual and later they focus on the safety group cultural behavioral.

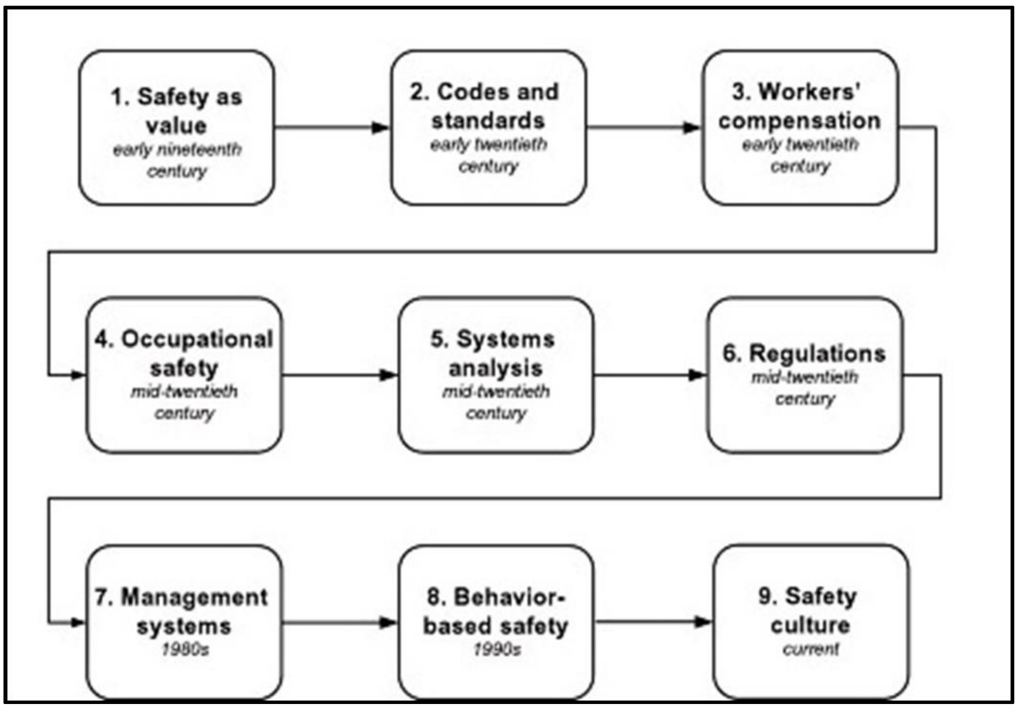


Figure 20: The safety engineering system development in oil and gas construction (Sutton, 2014).

In this research, the questionnaire will focus on the employee welfare aspect in either housing or work place as well as how it affects the safety performance of the labourers in the construction stage. Moreover, employee development will be examined to determine the professional strengthening such as training courses and workshops that the organization provides to the employees to improve their safety awareness in the field.

3.2.Distributing the questionnaire

The questionnaire targeted all employees working on the oil and gas construction projects in UAE. There are three main categories or classifications for the construction companies: owners (government sectors), contractors, and vendors, where most of construction projects are located in the onshore fields. As UAE is one of the leading countries in the onshore oil and gas industry, the onshore oil and gas construction projects are considered priority projects given their association with drilling, production, and development. This explains why construction contractors are more readily available in onshore rigs as opposed to offshore rigs.

Consequently, the majority of the questionnaires in this research where distributed in onshore construction rigs. Most construction rigs are located in remote areas both for onshore and offshore fields, rendering electronic communication difficulties. Personal visits are required to ensure that the targeted employees from the management to the construction end-user level receive and understand the questionnaires. In this research, 10 personal trips to different construction rigs, including 7 onshore and 3 offshore construction rigs, were conducted to distribute the questionnaires. The onshore construction rigs where located in Asab, Bab, Bu Hasa, Sahil, Shah and North-East Bab (Dabbiya, Rumaitha and Shanayel). These construction sites are linked by more than 450km of pipeline, with storage and shipping services available at Jebel Dhanna station (ADCO, 2012). For the offshore construction rigs, the questionnaires were distributed to the three major construction sites: Umm Shaif, Zakum and Das Island, where these fields are connected through a pipeline network as shown in Fig. 21.

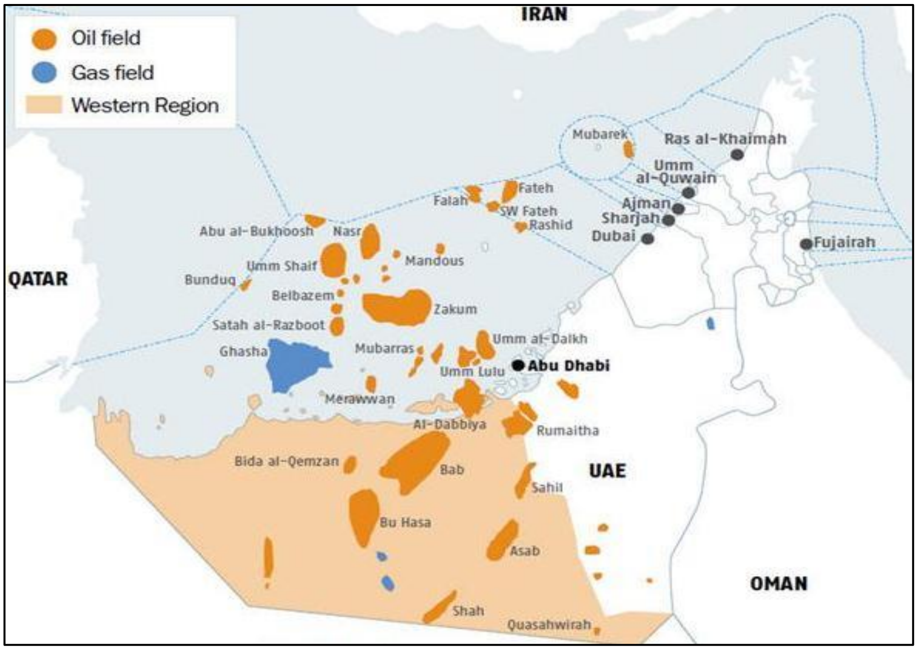


Figure 21: Onshore and offshore oil and gas construction rigs in UAE (ADCO, 2012).

As shown in the Appendix A, the questionnaire contains three aspects: technical, procedural and behavioral, which will help identify all strength and weakness aspects of the risk assessment that is used in UAE's oil and gas construction rigs. This inclusive approach can be considered the first stage to achieve the research aim of developing a comprehensive framework to optimize the safety engineering system of the oil and gas industry construction projects in UAE. The technical questions in this survey focus on the level of understanding of the main safety studies used in oil and gas construction such as HAZOP, HAZID, EIA and etc., and how risk assessment mechanism is being applied in these studies. This will illustrate not only the technical capacity and background of all employees from management to construction end-user, but also what the current and potential technical challenges arise in risk assessment.

Monitoring and communication are the most essential elements that the questions cover where many scholars believe that risk assessment in construction should be engaged throughout the life process and phases of construction projects. According to Zavadskas et al., (2010) to ensure the implementation of risk assessment in construction, there should be a continuous follow-up plan that monitors the quality of execution in all the basic five stages of construction: initiating, concept, planning, organization, and finishing as explained in Fig. 22.

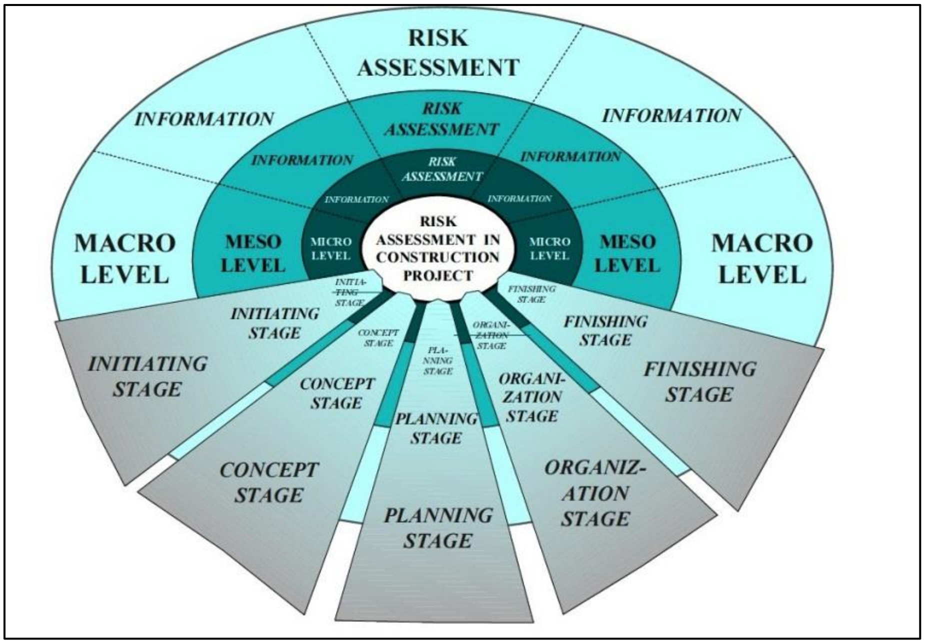


Figure 22: Risk assessment life cycle in construction (Zavadskas et al., 2010).

3.3. Interview

The interview structure will be divided into five sections as shown in Appendix B which cover the following areas: general information, risk assessment mechanism, procedural challenges, safety culture and technical safety. The first section aims to examine the interviewee's background in oil and gas projects and how he/she is involved in the construction activities through various undertaken responsibilities. Following this, generic questions about safety engineering system performance and implementation will be asked to determine his/her opinion about the current safety measures against all the possible hazards in the construction industry. After that, the second section will cover the reasons pertaining to the weakness of risk assessment. Direct and comprehensive questions will be directed to the interviewee to give him/her more flexibility in elaborating on the risk factors and recommendations that can be employed to enhance the risk assessment implementation. In the third section, the focus will be about why many construction organizations do not pay the required attention towards the safety regulations and procedures e.g. not updating the procedures and lack of enforcing the safety standards. The interview will also examine the interviewee's opinion about the government's role in ensuring the efficiency of the organization procedural schemes in the Middle East.

Two main interviews will be conducted in this study. The purpose of conducting these interviews is to recognize the root causes for the risk factors affecting the implementation process of safety engineering system. Many safety engineering scholars use the interview method as a method at the experimental stage of the construction activities related research. For example, Törner and Pousette (2009) employed the interview approach to determine the influential factors that increase the gap between the construction workers and managers.

3.4. Development of a new framework

This research study will propose a framework that is based in the outcomes of both of the questionnaire and interviews phases. As this study is try to examine the gaps from all the different aspects, this framework will be divided into three main categories: technical, procedural, and behavioural. This classification of the framework can significantly aid this study to achieve its aim. For example, if the management is willing to enhance the safety performance in the organization, a specific plan is required to be applied in an efficient and focused approach. In addition the presence of clear and integrated framework in the organization can provide visible communication channels, especially for the workers in the site to maintain high safety performance. For instance, as shown in literature review in Chapter 2, many major safety incidents happened in oil and gas industry due to the absence of safety communication scheme e.g. Piper Alpha.

To avoid such kind of disasters, this framework will display how non-technical elements such as behavioural safety can disturb the whole communication process in which eventually affect the safety performance of the workers. For that, as it will be shown in this framework, the connection and mechanism between the elements of these three categories are displayed. This will help the senior managements to fully understand all the potential hazards that are associated with the construction activities and give them the chance to act proactively towards a safer culture. By applying this approach, the decision making step becomes more noticeable for the managers where they may require this visibility due to lack of safety information of the construction site. As a result, better understanding and decision making will arise along with the risk assessment implementation. The systemic roles of framework inputs are explained in detail in Chapter 6.

3.5. Qualitative and quantitative validation

To ensure the effectiveness and feasibility of the proposed framework, it is needed to validate it in both qualitative and quantitative research approaches. Since the aim of this study is to enhance the safety implementation, the framework should be adoptable and practical for the all employee in the organization. That is, as in the interview stage, safety construction professionals will review the framework and discuss the potential challenges that may face the applications of the framework. The qualitative validation is conducted via construction manager and site supervisor to determine different views from all employment categories in the organization. The involvement of the end-users through the supervisor validation will add several advantages to reinforce the implementation process. For instance, according to Hale and Borys believe (2013), due to the poor involvement, variety of the safety frameworks has not been efficient and difficult to be understood by the workers.

However, since this framework is designed for the construction industry, a quantitative validation is advised to support the usage of this framework. In construction, there are numbers of safety KPIs where most of them are reactive ones. The utilization of proactive KPIs is one of the major current gaps in the safety engineering system. For that, in this research study, a new concept, Total Positive Outcome Indicator (TPOI), is employed to determine the amount of effort that is put to enhance the safety performance. To be aligned with the main perception of framework, integrated examination, technical, procedural, and behavioural indicators will be essential part of TPOI calculation. Selecting the indicators will be the first step to apply TPOI. Here, calculating the spent man-hours is the next step (for each indicator) to quantify the consumed positive effort and energy. However, to correlate these performance indicators and their role in improving the safety performance, they should be displayed with known safety KPIs such as Total Recordable Incident (TRI). In this study two hydrocarbon construction projects have been selected to apply the performance indictors to their safety statistics.

3.6. Summary of the chapter

The behavioral feature in this questionnaire will focus on the employee welfare aspect whether at home or work place and how it influences the safety performance of the labourers at the construction stage. Moreover, employee development will be examined in this method to determine the professional strengthening such as training courses and workshops that the organization provides to the employees to improve their safety awareness in the field. Zohar (2000) believes that examining behavioral employees, especially end-users, can help identify the senior management safety leadership and the quality of the internal communication between the organization employees.

The sampling method chosen for the questionnaire of this research is stratified random sampling. Many safety engineering professionals consider stratified random sampling an effective to measure the safety performance in construction and various other industries. For example, Hofmann & Stetzer (1998) explain that using stratified random sampling in construction safety can help produce diverse experimental cells that contain managers and construction labourers from various owners and contractors companies in a way that gives a precise representation for the targeted population. In addition, Aksorn & Hadikusumo (2008) agree in utilizing stratified random sampling as a desirable statistical to analysis safety factors in construction due to the different companies with diverse responsibilities that are involved in the same construction project. As such, stratified random samples were selected in this questionnaire. Under the 95% confidence internal for a population of about 4000 employees and a margin of error of about 5%, a representative sample size was calculated to be around 350 employees. In this research work, 355 responses (42 managers, 313 labourers) was collected it.

The questions in this interview will be focused on the areas that highlight the main safety concerns that were exposed through the questionnaire, such as risk assessment weaknesses, absence of consideration of human factors in the safety system, and gaps in the equipment safety. To gain an integrated perspective on these issues, two interviews will be conducted in this research. One of the interviewees holds a senior managerial post and the other holds a supervision role at the end-users in the construction workplace. Comparing their answers will illustrate the difference in opinion of management and the labour force in the organization.

According to Fung et al. (2005), one of the best method to determine the safety culture defects at the construction site is questioning the decision makers (managers and above) evaluation of the labour’s safety performance. Simultaneously, the authors stress the importance of capturing the end-users’ assessment regarding the organization top management disciplines and strategies to implement safety in the oil and gas construction sites.

Finally, to meet all the objectives, a validation processes will be applied to the developed framework. This framework provides a new concept on how the risk assessment can be utilized in a way that can be better integrated with all the work attributes at the construction site. The needs of an integrated examination in hydrocarbon construction projects have been mentioned by several academic professionals, as discussed in Chapter 1 and 2. However, it is vital to validate this framework from an industrial perspective by quantitative and qualitative approaches to determine its suitability as a method. As suggested in this study, the safety KPIs should be orientated towards the time and effort spent in implementing the safety system. As a result, leading indicators need to be used to examine the effort of both management and workers to provide safety environment at the workplace.

In the end of this chapter, Table 4 summaries the methodology approaches for each objective in this study:

Table 4: Methodology approaches for the study objectives

Objective	Methodology
Objective 1 Evaluating the current defects in the risk assessment as a method used in the safety engineering	**Methodology for Objective 1** Questionnaire
Objective 2 Examining top risk factors in UAE oil and gas construction projects	**Methodology for Objective 2** Interviews
Objective 3 Developing a framework to enhance the application of risk assessment for optimizing safety-engineering system	**Methodology for Objective 3** Analyzing the results of the Questionnaire and Interviews
Objective 4 Validating the developed framework through industry professionals	**Methodology for Objective 4** Quantitative and qualitative Validations

Chapter 4: Data analysis and discussion

4.1. Introduction

The questionnaires start with demographic questions such as age, employer, gender and job position where these kinds of questions will provide a better approach and understanding in the result analyzing stage. This will result on providing an effective integrated framework for the targeted populations in this research. The first question in the general demographic question section starts with inquiring the type of the construction company that the employer works in it (e.g. owner, vendor, and contractor). The majority of the responses in this questionnaire came from owner companies represented by government companies such as Abu Dhabi Marine Operating Company (ADMA-OPCO)) and international contractor companies such as Consolidated Contractors Company (CCC). An estimated population number was determined to enable the calculation of an optimum sample size for the questionnaire.

4.2. Statistical significance

In this research work, Z score test was applied to verify the statistical significance for the following statements in the questionnaire where several scholars such as Goncalves et al., (2007) suggest using Z score test (two tailed) with stratified random sampling method as it provides the flexibility on assigning the weights for the variables. Supporting that, Lee et al., (2007) use Z score test as a statistical approach to determine the level of safety culture in different industries including construction.

The following equation and parameters were used for the Z score test:

$$z = \frac{P1 - P2}{\sqrt{P(1-P)\ (\frac{1}{n1} - \frac{1}{n2})}}$$

Equation 1: Z score test Equation for two Populations.

n1= Total number of Population 1 (42 Managers).

n2= Total number of Population 2 (313 Labours).

P1 = Proportion (or total number) of individuals from sample Population 1 (**n1**) that agree or strongly agree with the statement of the question.

P2 = Proportion (or total number) of individuals from sample Population 2 (**n2**) that agree or strongly agree with the statement of the question.

Confident Level (CL) = 95%.

Pooled sample proportion (P) = (p1 * n1 + p2 * n2) / (n1 + n2)

M= Managers

L= Labours

4.3. Analysis of the results

- **Demographic questions**

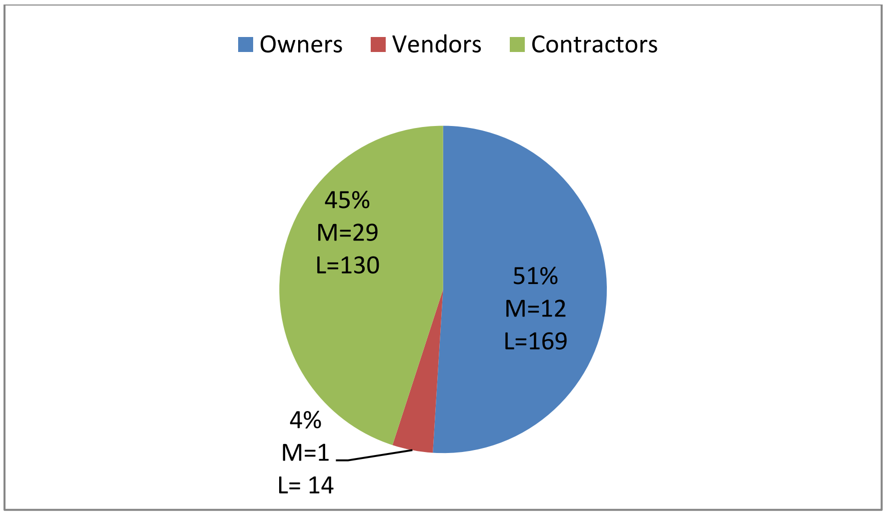


Figure 23: Type of the construction company.

Fig. 23 shows that 51% of the respondents are working with owner companies, 45% with the contractor companies and only 4% working with vendors companies. These numbers reflect the realistic employment landscape of UAE oil and gas construction industry in which most employees at the construction site at oil and gas rigs are either from owner or contractor companies. A vast majority of the responses came from males (92%) as shown in Fig. 24. This is due to the nature of the culture and physical requirements of the construction labourers role.

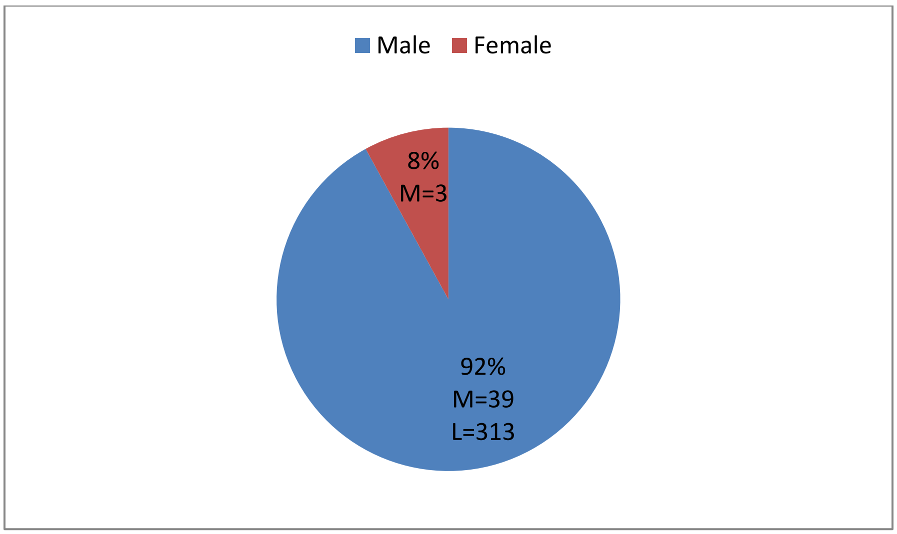


Figure 24: Employee gender.

Most employees participating in this survey were of the age between 20 and 50 as Fig. 25 explicates. Of this, 30-40 years old employees are the majority (33%). The explanation for that is that many employees in the oil and gas construction field usually get to the seniority or managerial post when they are 40-50 years old. As explained above, work in the oil and gas construction projects demands physical and mental wellbeing and as such, many employees tend to retiree when they reach age 50. This explains why only 7% of the targeted population was above 50 years old. For the fresh construction workers, they start their career at a very young age, ranging from 17 to 19 years old.

However, this questionnaire displays that both experienced and fresh construction labourers share the same education levels, which is a basic level. Fig. 26 illustrates that most construction labourers find it very difficult to communicate in English, which poses a severe challenge to understand the safety producers and manuals made available at the construction rig.

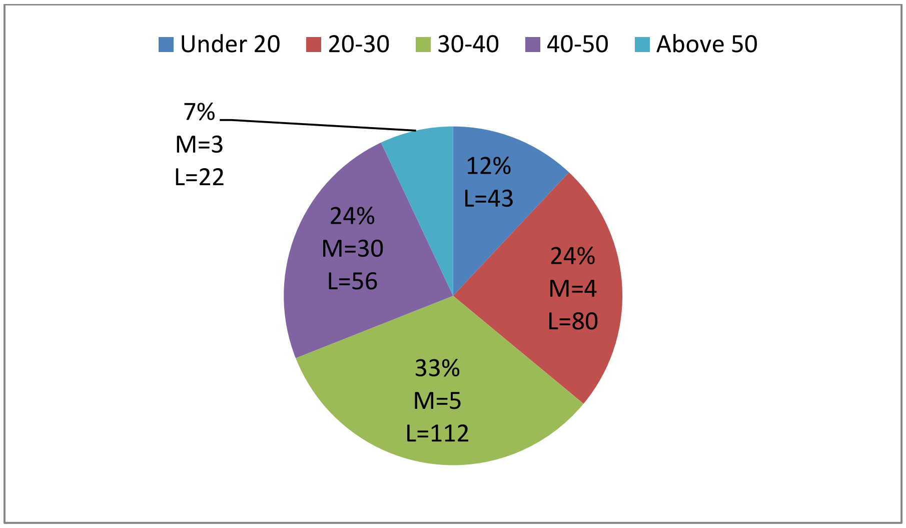


Figure 25: Employee age.

By comparison, supervisors and administrative employees boast high school or university diplomas which assist them in conducting the documentation work in their job duties.

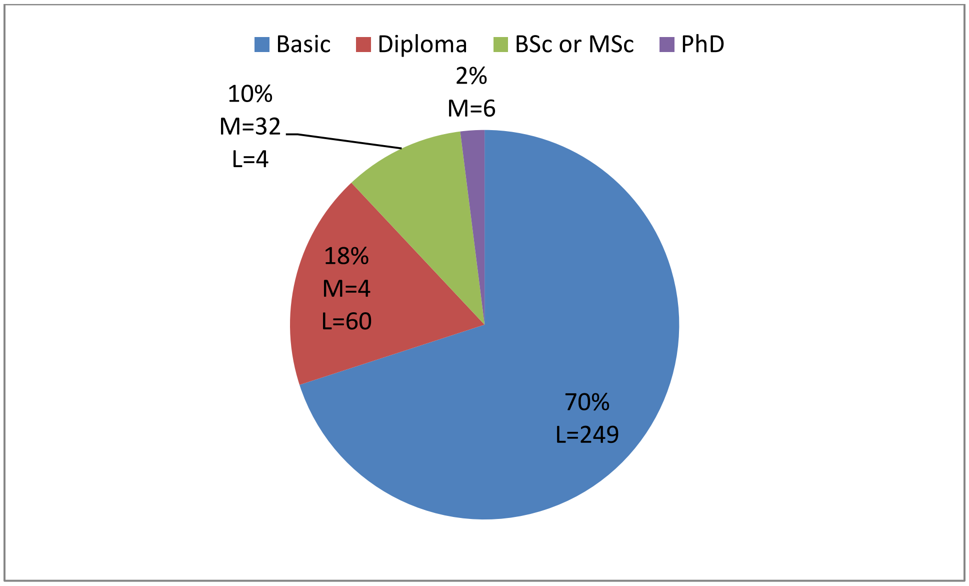


Figure 26: Education level of employees.

Bachelor and Master Degree holders occupy the leading roles in the organization, such as fresh engineers all the way up to senior engineers and senior manager posts that have a significant authority at the construction field. It can be seen from Fig. 26 that there are three main classifications with respect to the education level in construction:

- Basic education (70%)
- Diploma (18%)
- Bachelor or Master Degrees (10%)

Employees with PhD degrees usually work in the corporate offices and they come to the construction rig as temporary assignment to conducted courses for other employees as part of the employee development plans in the organization. This explains why only 2% employees hold PhD degrees.

In terms of job position demographics, there are two classifications to select: end-user (labourer and technician), and senior staff (managers and senior managers) as evidenced by Fig. 27.

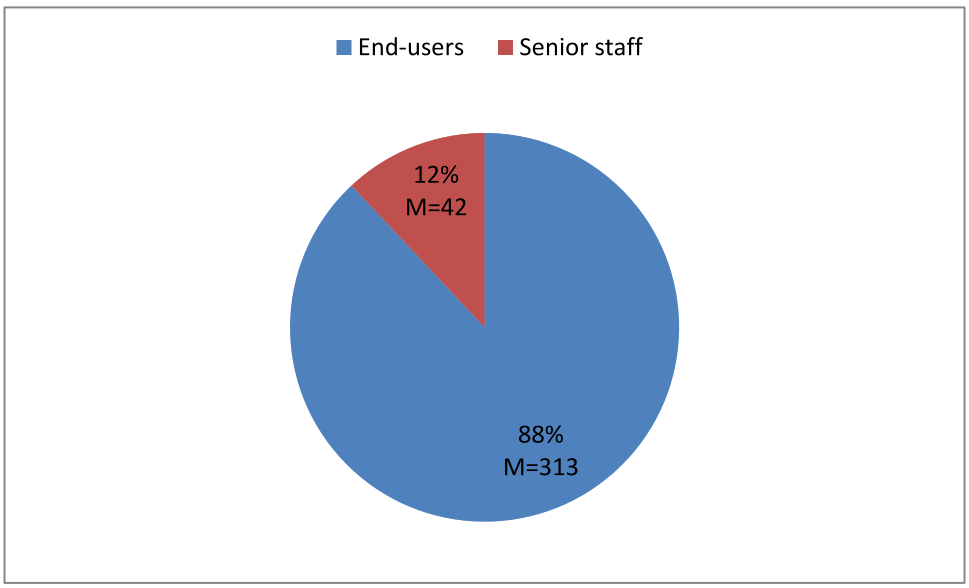


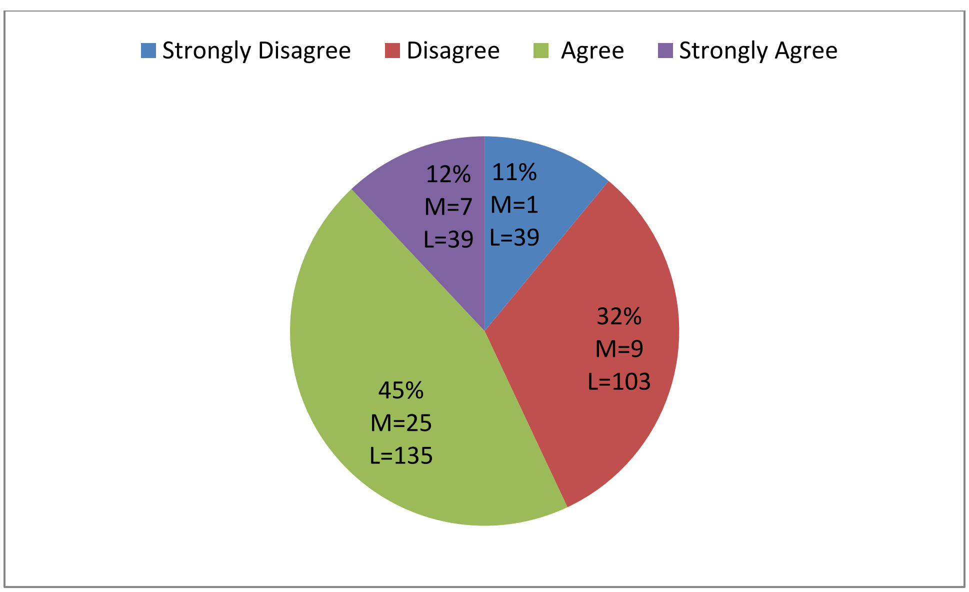
Figure 27: Job position for the employee.

The results in Fig. 27 simulate the reality of job position distribution in the most construction companies, especially in UAE. To illustrate, Al-Kaabi and Hadipriono (2003) mention that the majority of the employee of the construction companies in UAE are the construction workers, which is the reason why the level of risk exposure and accident rate is high in UAE. However, the authors believe that even if the mainstream of the employees at the construction organizations are labourers, the focus of safety engineering implementation should not be only narrowed for this group but should involve all the organization employees from the top management to the end users level to ensure safety culture at the construction site.

The aim of the next section in the questionnaires is to examine the employees' familiarity with safety practices and procedures inside the organization and at the construction site. Having the required safety knowledge is vital for them to enhance their risk assessment implementation skill. According to Liaudanskiene et al., (2009) being familiar with the company safety manuals and producers provides employees a clear perspective on how to apply the safety instructions for the construction activities.

- **Technical/Procedural/behavioral questions**

The first question in this section scrutinizes how employees feel about the strength of their HSE MS and its strength as procedural and applied system in the organization.

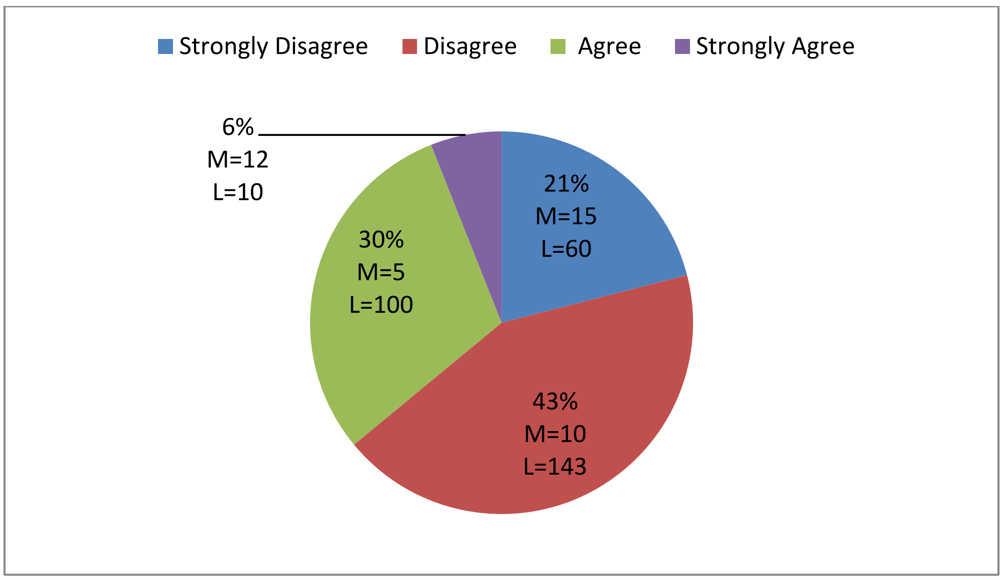


Z value= 2.541 , P value= 0.011

Figure 28: The company has a strong HSE management system.

Fig. 28 displays that 45% of the employees agree that their companies have a strong system whether from the procedural and technical perspectives while 32% do not agree that their construction companies provide a strong HSE MS. In this question most employees who strongly agree about the high strength of the HSE MS (12%) were from the senior staff especially from the top management. Conversely, the 11% who do not agree are from the end user classification (labourers and technicians). These results show that there lack of agreement about how strong the HSE MS is between the oil and gas construction companies in UAE.

The next question was geared towards gauging the knowledge level of the employees with risk assessment such as methods that are used in their construction companies in the oil and gas industry.

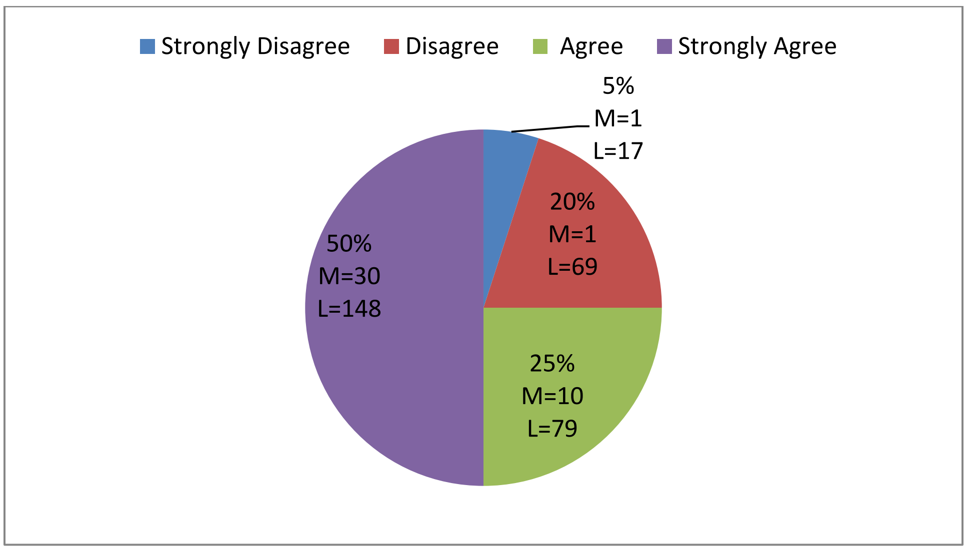


Z value= 0.677, P value= 0.496

Figure 29: You are familiar with risk assessment methods.

Based on Fig. 29, one can argue that most employees lack sufficient knowledge of safety systems. The 43% who disagree are from the end users employee category. This can indicate a lack of training for the construction labourers which can cause serious safety issues due to the high exposure level with all identified potential hazards. To avoid any of these incidents because of lack of risk assessment skills, Schieg (2009) suggests that risk assessment courses should be available for all the employees in the organization, including labourer and technician, where many of the construction companies try to improve the risk assessment skills only for senior decision-making staff. The author believes that a common error that construction companies make is their beliefs that risk assessments are only conducted in offices. Upon analyzing Fig. 29, it can be noticed that 21% strongly agree on the familiarity with risk assessment methods and all of these responses came from senior engineers or managers. This supports Schieg statement about how construction companies predominantly focus upon developing the risk assessment skills for the senior staff without involving other employees.

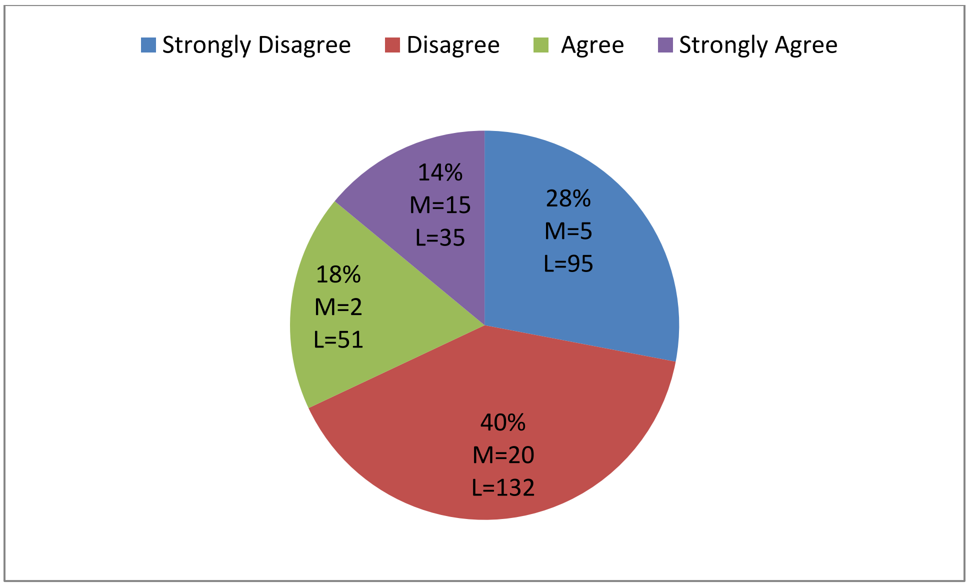
The next question tackles a crucial point related to organization behavioral safety. The question attempts to explore the incidents reporting culture at the facility, where different construction companies have different attitudes towards the reporting system.



Z value= 3.201 ,   P value= 0.001

Figure 30: LTI accidents are always reported in your company.

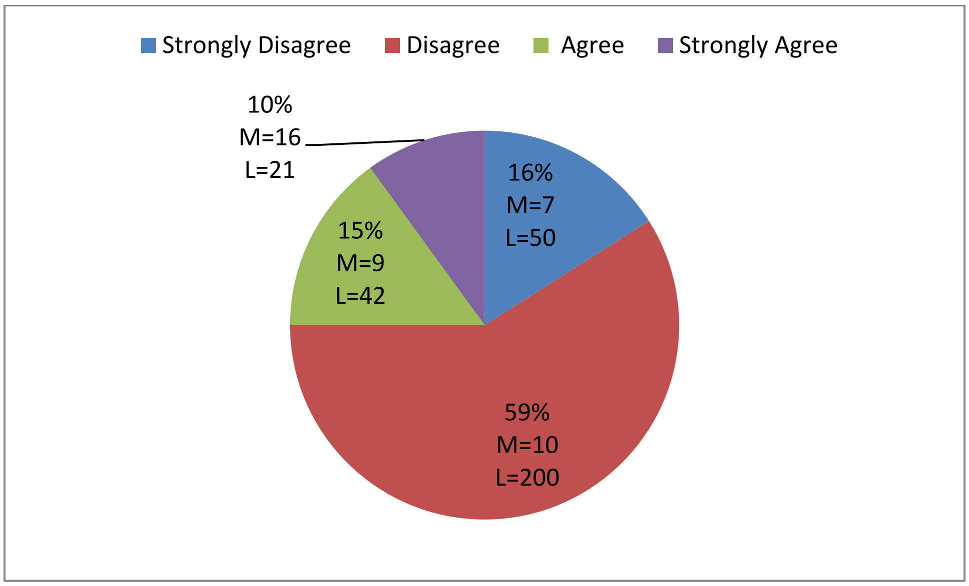
The question, as illustrated by Fig. 30, pertains to if your construction company reports all LTI incidents that occur in the field in which displays the organization commitment towards exposing the gaps and the defects that they have in their safety engineering system. According to Macrae, (2007) that the practices of reporting the incident in the facility have a direct and effective impact on the risk assessment implementation on the individual employee and this is because, these practices represent the visibility and leadership of the organization. Therefore, if the employee finds his/her organization practice healthy reporting system without hiding incidents or using blaming culture against the violator, he/she will report all the defects in the used risk assessment thus advancing the implementation process. From Fig. 30, it can be seen that 50% of all employee strongly believe that their construction companies report all LTI incidents, which shows a healthy reporting system in the oil and gas construction industry. 20% of the employees, who disagree about LTI reporting system, mostly came from vendor companies which are often unfamiliar with the reporting system.



Z value= 3.201,   P value= 0.001,

Figure 31: Your Company's provides enough training to ensure safety competencies level between its employees.

Fig. 31 explicates one of the most important points regarding the employee development i.e. the professional safety development at the construction organization. Champan (2001) claims that most construction companies do not provide technical safety courses for their employees. This is especially true in the case of construction labourers. This explains why many of the end user staff lacks even the basic understanding of safety construction procedures in their organization. This is the reason why the question mentions the word “enough” to examine the respondent’s opinion about the training courses that he/she is receiving. As shown in Fig. 31, 40% (mostly senior staff members) do not believe they have enough safety courses required for their jobs. Additionally, 14% who strongly disagree about the current safety courses hold managerial posts. This is shocking because construction companies should provide their safety managers with high quality and integrated safety training courses to ensure senior staff competence because they represent the organization leadership and visibility. It is essential for end user employees to see their line supervisors and managers displaying high quality safety skills which in turn encourage them to follow and implement the safety engineering system at the construction site.



Z value=5.552 , P value=.0.0

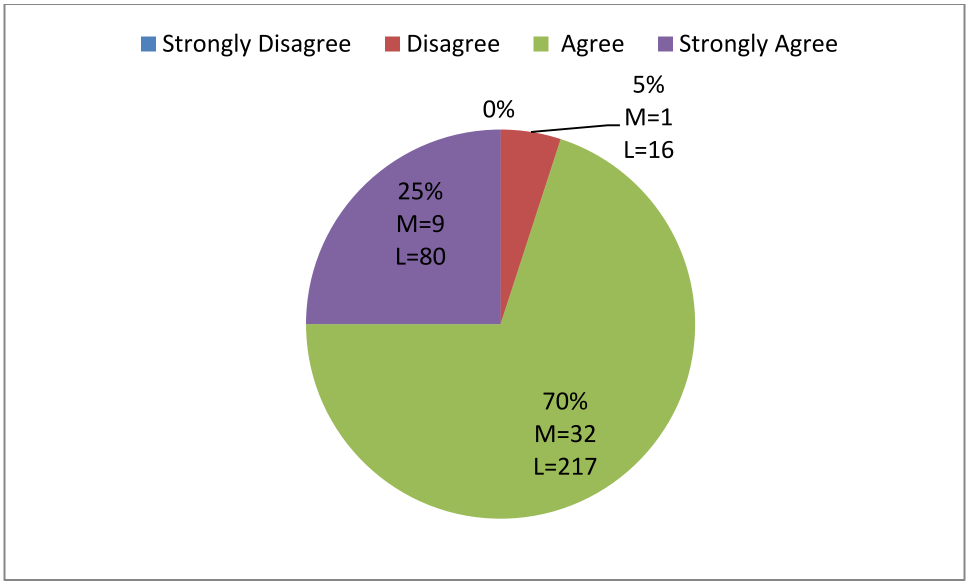
Figure 32: There are efficient communication channels between the management and the labourers.

To practice this healthy and safety relationship between manager and end users, clear and effective communication should be in a place inside the construction organization. Communication can be the most important element for the whole safety engineering system in construction field especially in the emergency situations where ambiguous communication in the facility, can lead to poor safety control and mitigation of hazards. This further leads to serious accidents at the construction sites. Pinto et al., (2001) mention that poor risk communication, which can occur because of variety of external and internal factors, creates a gap between managers and employee thus impacting the implementation process in the safety engineering system.

Fig. 32 explains how most employees (59%) in construction companies believe they lack efficient communication channels in their organizations and majority of the employee who disagree and strongly disagree are construction workers. Communication represents the key that they need to use in their safety daily job duties whether to receive the managerial instructions from the senior staff or translate, supervise, and implement them to the labourers. The 10% who strongly believe the efficiency of the communication are from the very top management such as constructions managers and vice presidents of the organization, as shown in Fig. 32.

On the flipside, only a few construction labourers and technicians agree on the quality of the communication channels. This may be due to the communication mentality for the senior staff inside the construction facility in which they do not properly deal with all external and internal factors that influence the integrity of the safety communication. For example, Kine et al., (2010) mention that senior management at the construction companies should include factors such as work involvement and education levels of foremen in their communication plan from the design phase until construction phase. This helps the implementation process of the risk assessment.

The next question focuses on a critical aspect for safety implementation at the construction organization which is management, leadership and commitment. According to Zhou et al., (2010) BBS of the foreman can be a real challenge for risk assessment implementations due to their weak safety understanding and background. To overcome this issue, there should be a real influential example from the senior management to highlight the importance of implementing safety instructions at the construction site.

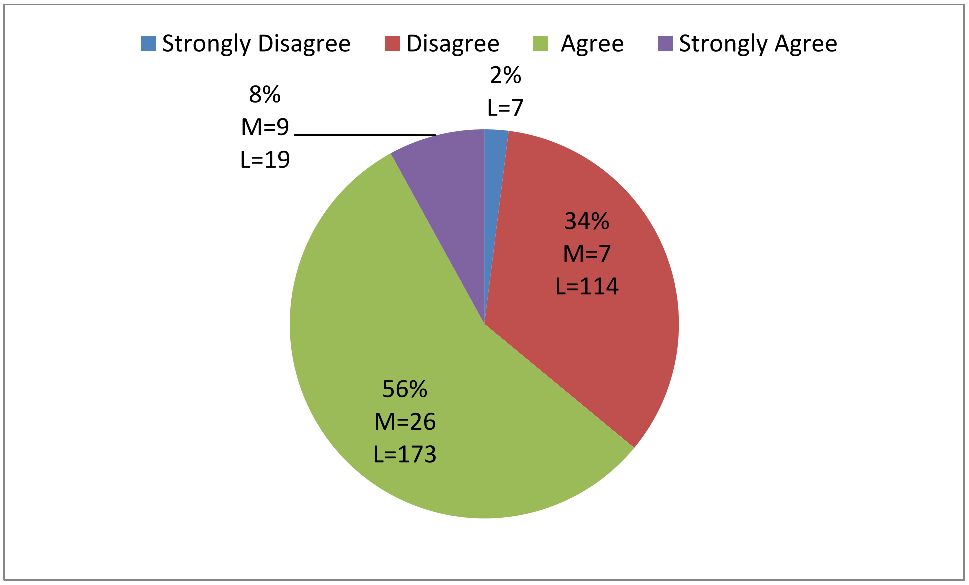


Z value=0.778, P value= 0.435

Figure 33: Top Management conducts regular safety tours to construction fields.

In this questionnaire, management leadership was examined through their commitment towards safety visits to the construction fields. As shown in Fig. 33, there are extremely high numbers of responses (70%) agree and (25%) strongly agree from all categories who believe the management leadership is present at the construction sites and this indicates a positive sign of the visibility of the senior management in the oil and gas construction industry in UAE. The presence of top management for safety tours and safety workshops has a great impact on the safety behavior of other employees. Most important it is the quality of these safety visits which can be ensured by effective listening and follow-ups with visit findings to enhance the risk assessment implementation progression (Zhou et al., 2010).

The questionnaire explores the procedural features and effects on the risk assessment implementation in the safety engineering systems in the individual and group level. The very first procedural document that any employee should have is the job description that highlights the employee's role and responsibilities including the safety one at the construction site.

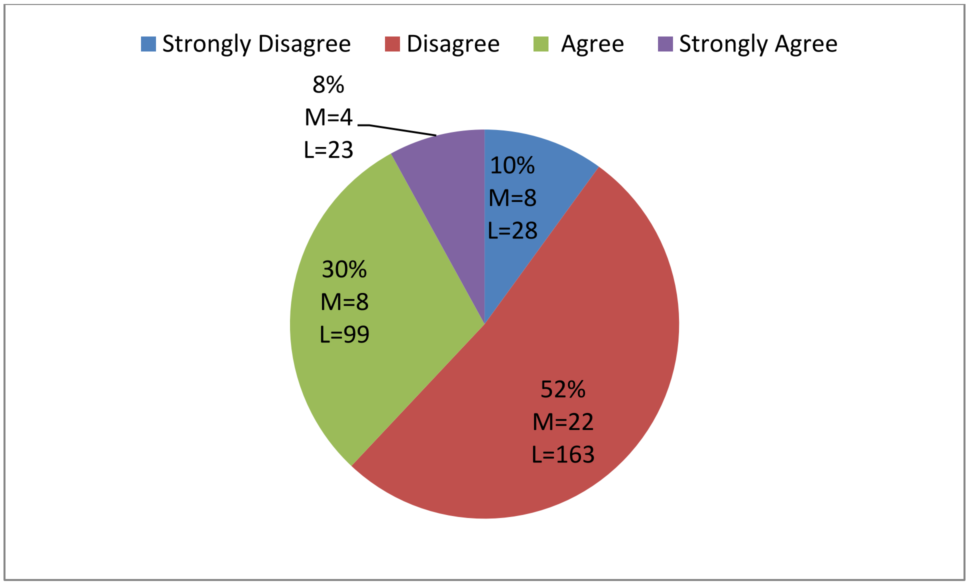


Z value= 2.787 , P value=0.005

Figure 34: You understand your role and responsibilities towards safety in your job.

As shown in Fig. 34 that there are two main responses for this question: first, 56% who agree that they understand their safety responsibilities comprise mostly of end user staff members. The second category of responses (34%) came mostly from construction labourers or top managers who lack a full understanding of their safety responsibilities on site. This is a highly troubling result because these two roles should have a solid understanding of their safety duties. Most construction managers in the oil and gas industry are held accountable for any safety incidents arising at the construction site. For the construction labourers, they should totally understand all technical and the procedural producers that are associated in their construction activities since they are highly exposed to all potential hazards at the construction field.

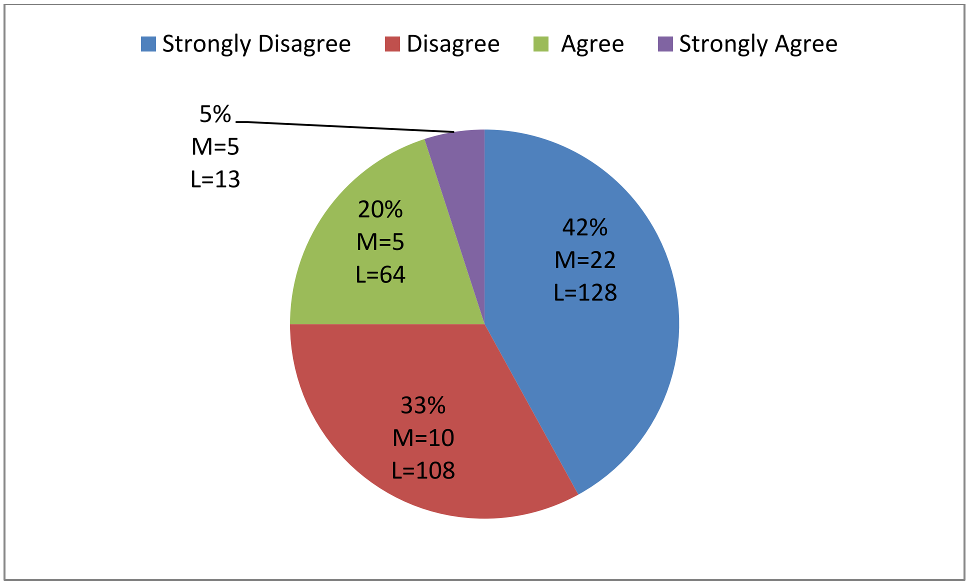
A contrasting result occurred when the respondents were asked about the employee individual understanding towards safety responsibilities of his/her line supervisor at the construction organization. Toole (2002) explains that it is extremely important for the construction employee, especially the foremen, to fully understand their line supervisor safety roles in order to recognize their own safety responsibilities.



Z value=-1.306 ,   P value=0.190

Figure 35: You understand your line supervisors' role and responsibilities towards safety in his job.

Fig. 35 shows that 52% of the employees do not know the safety roles of their line supervisors. As mentioned above, the lack of such information has a negative impact on employee's safety accountability. Conversely, most end user staff members agree 30% and 8% strongly agree, which is a strong indication that supervisors and coordinators are the most knowledgeable employee category when it comes to understanding supervisor safety responsibilities in oil and gas construction industry in UAE.



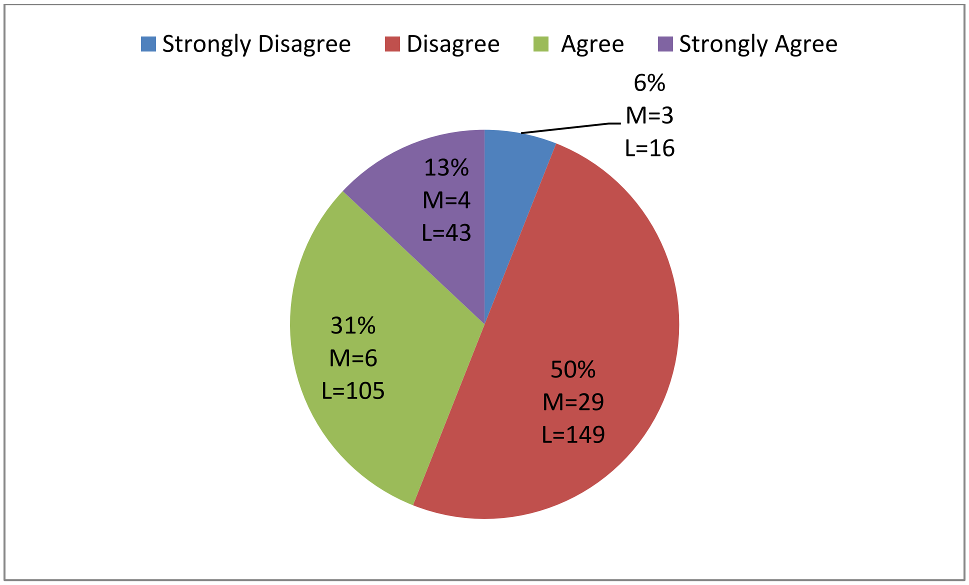
Z value=-0.111 , P value=0.912

Figure 36: Safety policies and procedures are up to date in your company.

The next question tackles the updating of safety policies and procedures inside the construction organization. According to Kartam et al., (2000) safety procedures plays a vital function in ensuring the safety at the construction sites where all incidents investigations mainly use the company safety procedures as primary reference for their investigation judgment. However, Fig. 36 displays extremely negative results where most respondents in all employee categories strongly believe that their construction company does not update their safety procedures. Kartam et al., (2000) illustrates that many of construction companies avoid the cost of updating the safety policies and procedures. In the long term, not updating the safety procedures may lead to serious violations against government regulations thus incurring severe ramifications. Furthermore, in case of a facility accident, it is hard for the insurance company to approve the construction organization claim if they do not have updated procedure that complies with the government regulations.

Following this, the questionnaire focuses on the procedural safety group awareness. Toole (2002) believes that it is extremely important to determine the general perspective of safety among the employee themselves at the construction site because it can give the level and maturity of safety culture at the construction site.

Fig. 37 displays that 50% of the construction company's employees (mostly managerial level employees) believe that their colleagues do not have a good understanding of the safety policies and procedures inside their organizations. Aksorn & Hadikusumo (2008) explains that the high number of employees at the construction industry, especially in the Middle East, have a major challenge to understand the safety procedures due to the lack of education. This leads to several difficulties in safety implementation on the site.

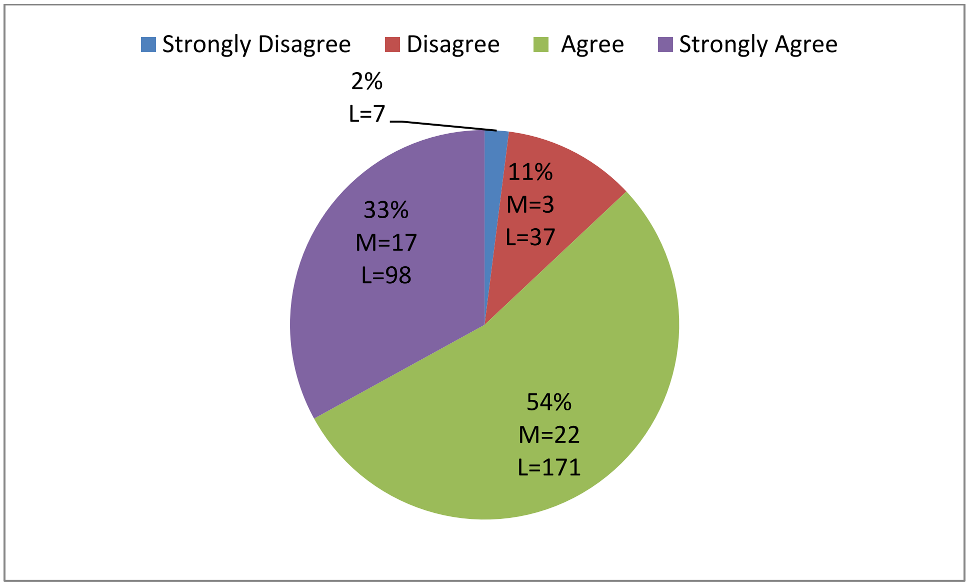


Z value=-2.874 , P value=0.004

Figure 37: Safety policies and procedures are well understood by employees.

The authors believe that construction managers can avoid these procedural challenges by simplifying the safety procedures and preparing proper safety induction booklet that illustrates all the required safety polices in a way that suits the capability of the construction labourers.

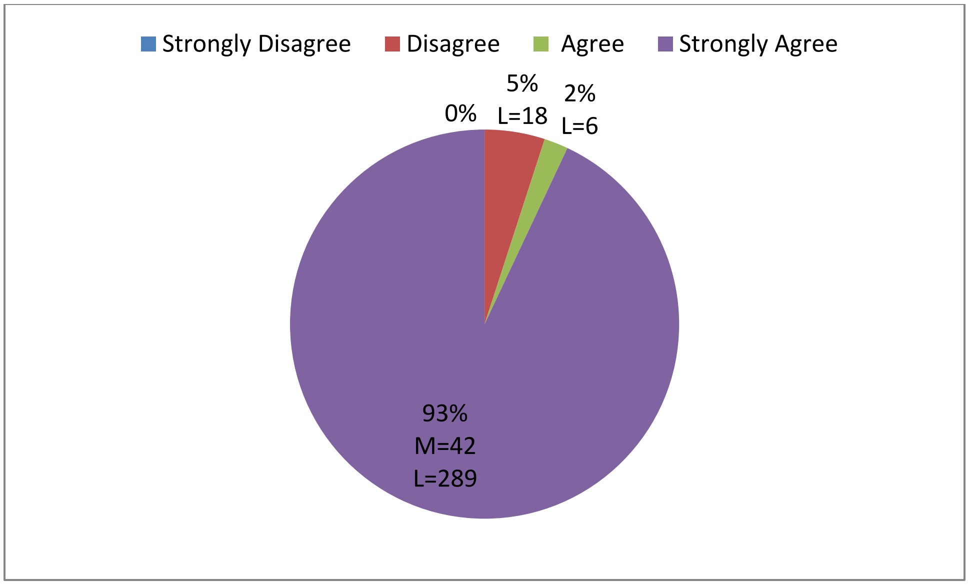
The next question focuses on the organizational practices that occur in every construction facilities and their role in implementing risk assessment. The following question, as Fig. 38 shows, asks respondents if they attend safety meetings in their own department. Usually there are various kinds of safety meetings at the construction companies where these safety meeting can be conducted in yearly, quarterly monthly, weekly and daily basis for different levels of the organization. Schultz (2004) claims that commitment of employees to attend theses kind of meetings reflects the employees' willingness to implement the safety measure in their duties. He adds that most employees from the top management to the foreman level have the intention to apply safety engineering system in the work cycle but they face obstacles in the way of its implementation, such as inadequate risk assessment. This explains why in Fig. 38 there is an enormous agreement (54% agree and 33% strongly agree, respectively) for attending the safety meetings in oil and gas construction companies in UAE.



Z value=1.241 , P value= 0.214

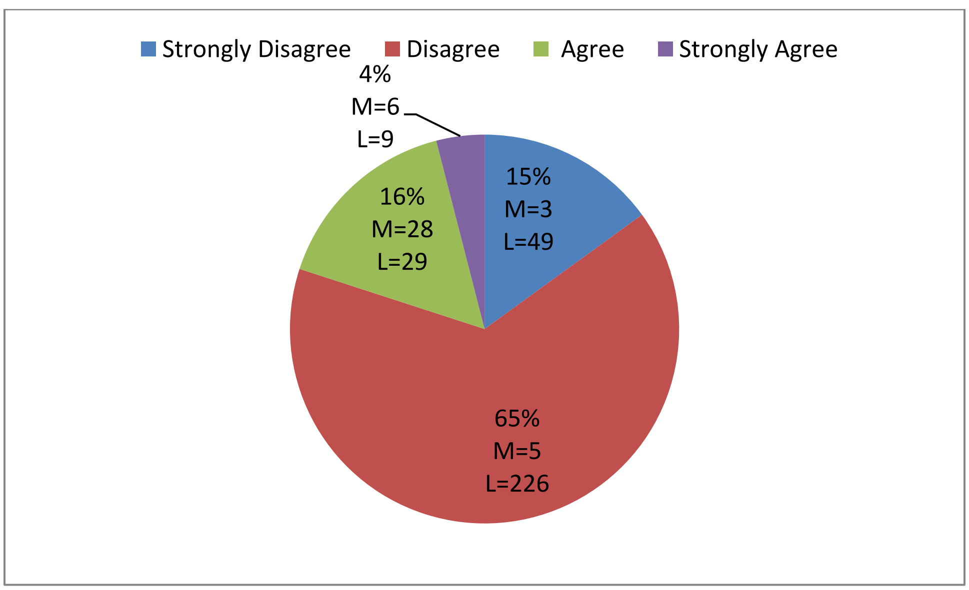
Figure 38: You always attended the safety meeting in your department.

As depicted in Fig. 39, respondents were asked if their construction organizations report all the fatal accidents at the construction fields. When compared to Fig. 30, one notices how almost all employees strongly agree that fatalities are recorded and reported. This may be due to the high severity of these accidents. For instance, Macrue (2007) states that it is difficult for any construction organization to hide lost human capital although unfortunately many try to avoid taking full responsibility by claiming they provide a safe environment in the work place.



Z value=1.858 ,   P value=0.062

Figure 39: Fatality accidents are always reported in your company.

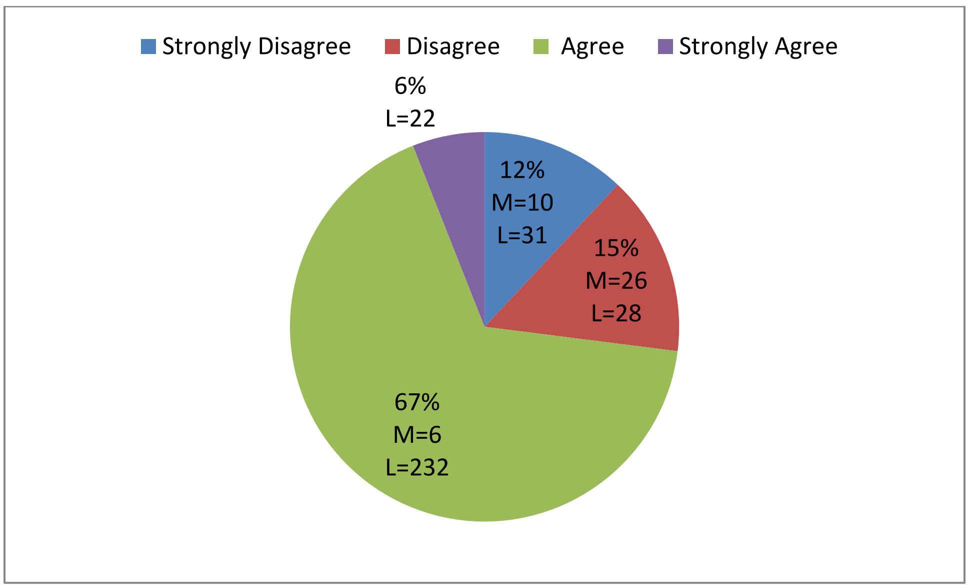


Z value= 10.413,   P value=0

Figure 40: The management provides safe work place for the end users employees.

The next question aims to evaluate Macrue's (2007) point by directly asking the employees if their management provides a safe environment at the construction site or not. As Mercure predicts, 65% employees disagree, with most responses coming from the end user employees. On the flip side, most managers responded with strong agreement (4%) that can be explicated as a defensive point view.

Extra work loading can have a significant impact upon risk assessment implementation at the construction sites. Bates & Schneider (2008) conducted a field experiment that gauged physiological, psychological and sociological effects of construction workers due to the work loading in UAE. The authors use questionnaires and interviews as a methodology in experiment where the data analysis show how most construction workers suffer from fatigue due to workload pressure and the work environment. That is, most labourers said that they often face pressure from their management to increase production rate without considering the employee welfare aspects. For example, many construction labourers in the summer time suffer from thermal stress, adversely affecting their safety performance. This in turn results in labourers falling victim to several serious, even fatal, accidents.

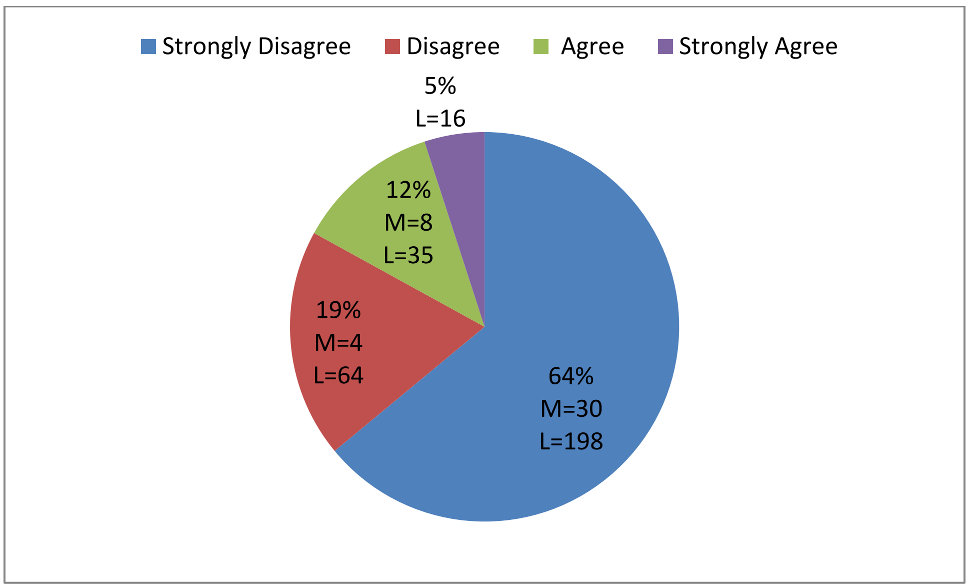


Z value=-7.746 , P value=0

Figure 41: End users employees face heavy workload pressure in their job.

The authors suggest that construction managers need to consider foremen welfare so as to ensure the safety in their construction activities and thus preventing human capital and economic loss. The questionnaire tries to examine the work-load level for oil and gas construction workers in UAE where Fig. 41 depicts how 67% employees believe that they are facing heavy workload. Many managers and senior employees strongly disagree with this statement, believing their workers do not face any extra load and that the current work load is within the workers physical and mental capacity.

While pervious questions in the questionnaire analyzed factors that can influence risk assessment implementation, the next question inquiries about the full implementation of this safety engineering at the construction field. There was strong agreement (64% strongly agree) from organizations employees in all the categories (i.e. Manager, engineers and labourers) as shown in Fig. 42. The results in Fig. 42 raise numerous vital questions on the contrasted responses about risk assessment implementation in the questionnaires so far. For instance, many senior staff members remain convinced that they provide all the necessary support from all different resources, materials, and equipment to ensure the safety environment in the work place.

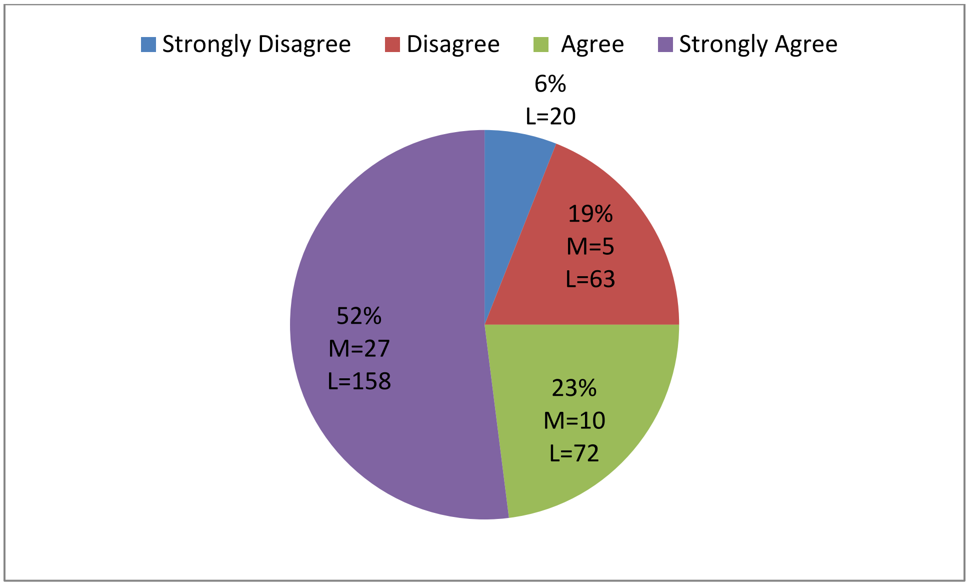


Z value= 0.4501,   P value= 0.652

Figure 42: Risk assessment is fully implemented in construction fields.

However, most admit to having major issues with the risk assessment implementation which is highly unlikely if the management employs visible leadership and adequate decision-making mechanism in its risk assessment procedures.

Koller (2005) expounds that most industries focus on the outcomes of the risk assessment from one perspective which leads to inadequate decision-making. This is applicable from the safety feature, where a variety of industrial companies tries to evaluate the risk assessment outcomes from the financial phase only. According to Koller this can be due to the limited understanding of integrated safety system or due to the shortage of resources such as materials, equipment and man powers.

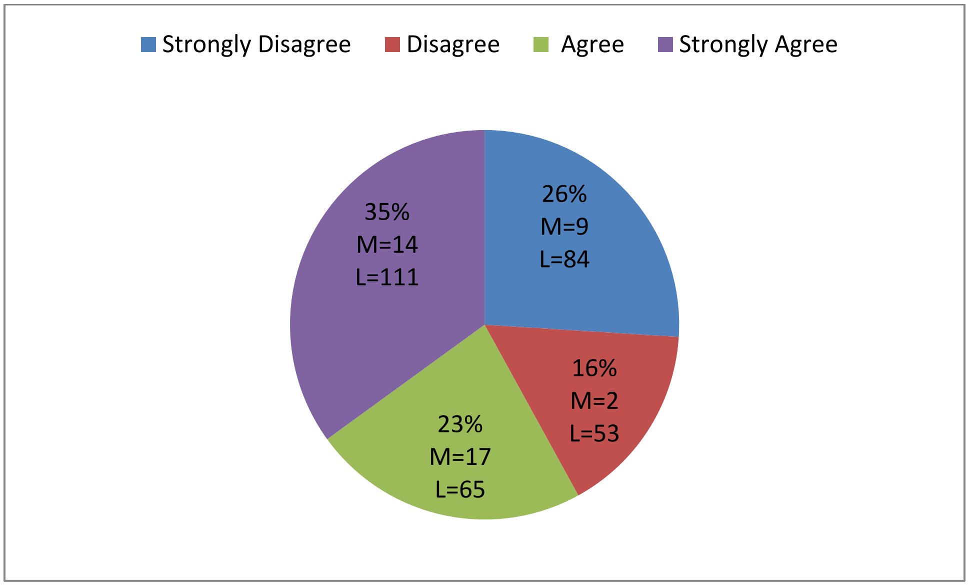


Z value=2.059 , P value=0.039

Figure 43: There is a poor decision making due to inadequate risk assessment.

Fig. 43 demonstrates the strong agreement among all the respondents that the decision-making mechanism is not that efficient and impact the risk assessment. The majority of the 52% of the respondents are holding a decision-maker role and this shows that the management at the construction organizations knows and admits about the weakness of the decision-making and its effect towards safety engineering systems. As expounded by Koller, this poor decision making process can be because of the lack of the knowledge or resources and to avoid these factors, the author suggests that the organization should establish a clear, updated and integrated decision-making plan as part of the organization strategic vision.

This brings the importance of the strategic plan of the organization and its safety performance in the oil and gas construction rigs. Jaselskis et al., (1996) explain that strategic development of construction facility usually displays the direction of the company construction operation plan, but to ensure the safety integrity, HSE plan should go in parallel with business plan. For instance, when the construction organizations aim to expand the construction activities, they need to increase the man power and resources to maintain the healthy and safe environment in the workplace. Fig. 44 illustrates how employees have different opinions about the effects of organization strategic plan on safety implementation.



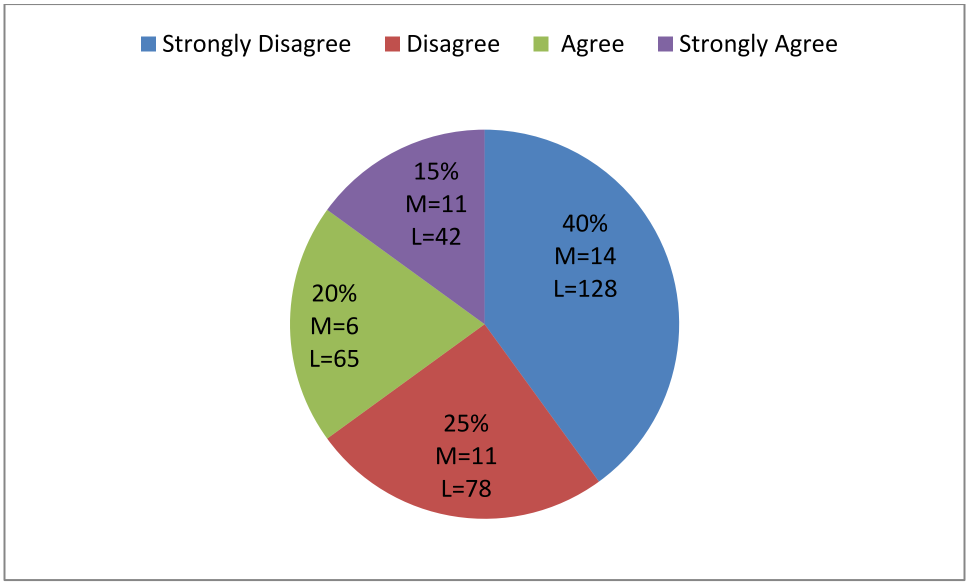
Z value=2.169 , P value=0.030

Figure 44: Safety implementation is a direct output of the company's strategic plan.

For example, 35% of the employees strongly agree with the safety role of the strategic plans, where most respondents were from the end user staff members that include fresh and young employees, engineers and coordinators. The reasons for that is that although these young employees have the technical skills to ensure the safety presence at the construction sites, to implement the integrated safety model in the site, a long-term vision is needed that should be initiated from the top management (Jaselskis et al., 1996). Moreover, the majority of foremen responded with disagree (16%) and strongly disagree (26%), indicating a lack of understanding of supervisor safety role as stated in Fig. 35.

The next question in the questionnaire evaluates the monitoring system at the construction companies in the oil and gas rigs. Communication is a crucial element in monitoring system and as illustrated in Fig. 33, there is major concern amongst the employees regarding the quality of the communication in their organizations. However, Fig. 45 presents what the employees think about the safety role of the whole monitoring system in construction activities.

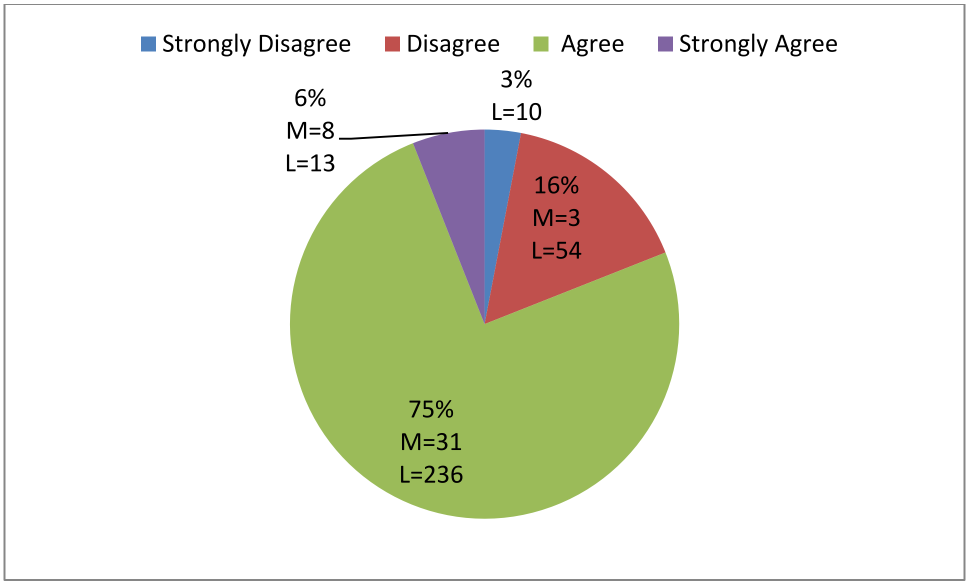
Not surprisingly, most employees strongly disagree with the efficiency of the safety monitoring system applied at the construction sites (Fig. 45). This matches the respondents' opinion about communication mapped earlier in Fig. 33. Naticchia et al., (2013) explains that many construction companies may have strong safety monitoring systems that cover different areas and protection layers such as PTW (procedural precaution), safety control (Technical), safety best practice (Managerial). However, the authors believe that the monitoring system could lose a lot of its strength if proper communication is absent because it contains a lot of planning initiates that require effective and clear communication channels.



Z value=0.803 , P value=0.423

Figure 45: your Company's provides an efficient and effective safety monitoring system towards safety issues in the construction fields.

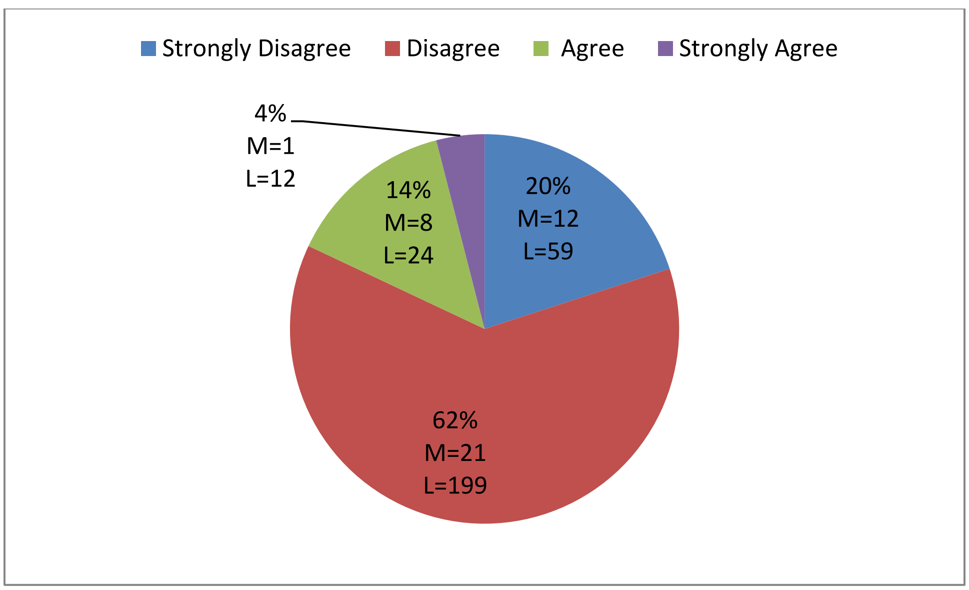
The next question examines the safety compliance of the organization by inquiring if the respondents' construction companies consider safety as its priority, shown in Fig. 46. A vast majority of the survey participants (75%) agree that safety is one of the most essential elements in their agenda and this proves the willingness of the oil and gas construction companies to apply safety. Simultaneously, however, it explains the management's struggle in implementing these safety systems.



Z value=2.069 , P value=0.038

Figure 46: Safety issues are priority for the management agendas.

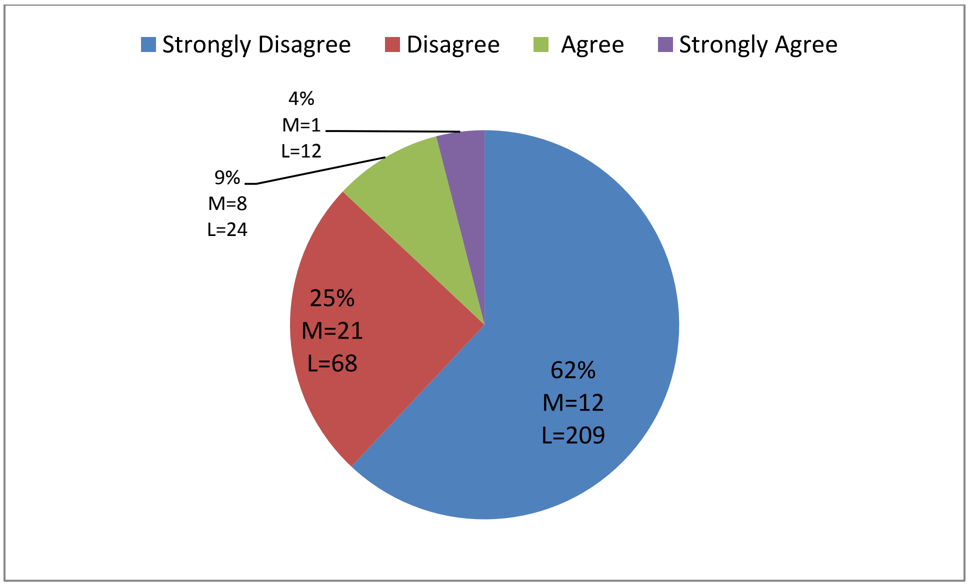
Legal enforcement is a critical element that can enormously help organizations implement safety systems at the construction sites and prevent potential accidents. For example, Tam et al., (2004) mention that one of the main safety challenge faced by the Chinese construction industry is laws and regulations enforcements.



Z value=1.815 , P value=0.068

Figure 47: There is strict enforcement of safe working procedures and policies.

The authors provide several reasons for this, one of which is the lack of the specific safety regulations bodies that ensure the implementation of the government safety legislations. According to the authors this enhances all different methods in the safety system such as risk assessment. As Fig. 47 illustrates, the questionnaire compiled the employees' response about the enforcement mechanism in their organization, where 62% do not agree about its safety effectiveness. It is not necessary that this number reflects the weak enforcement performance of the construction organizations because, as discussed in Chapter 2, there is major lack of federal government safety bodies that can supervise the construction activities in oil and gas industry.

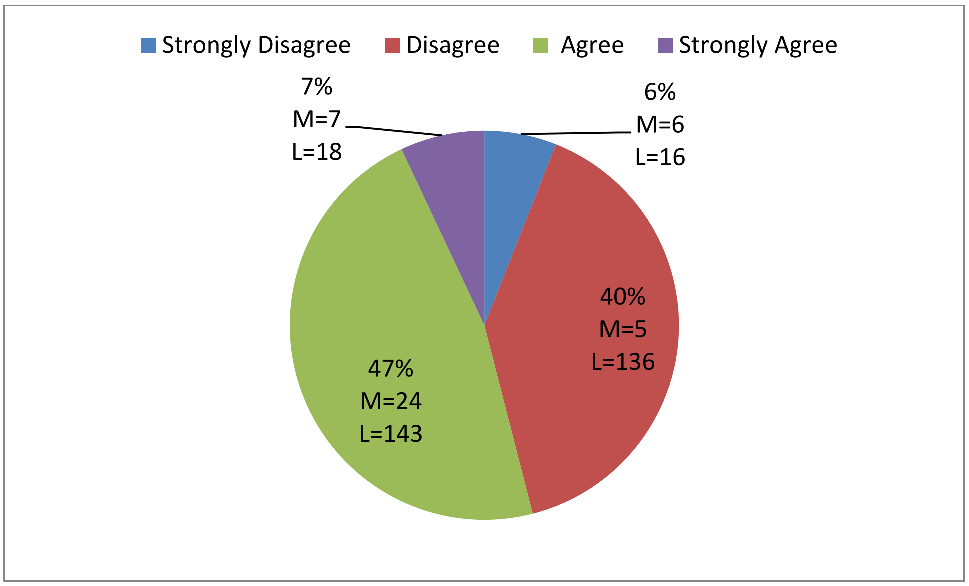


Z value=1.814 ,   P value=0.067

Figure 48: Construction workers are well motivated to work safely.

Ligard (2002) holds that safety motivation is the key element to enhance the safety behavior of the individual employee. This is especially true for construction labourers because it helps them avoid personal injuries and improve the occupational safety at the construction sites. Fig. 48 shows that there is a major issue regarding the safety motivation in the oil and gas construction companies in UAE. 62% strongly disagree and only 25% disagree in regard to the existence and efficiency of the safety motivation. According to Ligard this can be solved via organizational influences and practices such as establishing health and safety rewarding system for the foremen at the construction field. This highlights the importance of the organizational practices in implementing the safety system inside the construction activities.

Auditing can be considered best procedural control measures to ensure the organizational safety practices. Lund & Aarø (2004) debate that audits and inspection are tools for ensuring the integrity and the implementation process of the safety engineering system. However, the authors believe that most construction firms have implementation issues with the audit findings, where systematically, all the findings should be followed to ensure the required changes have been applied. Another critical point referred by the author is that many auditors do not focus on the integrity of the risk assessment mechanism employed in the safety system in the organization.

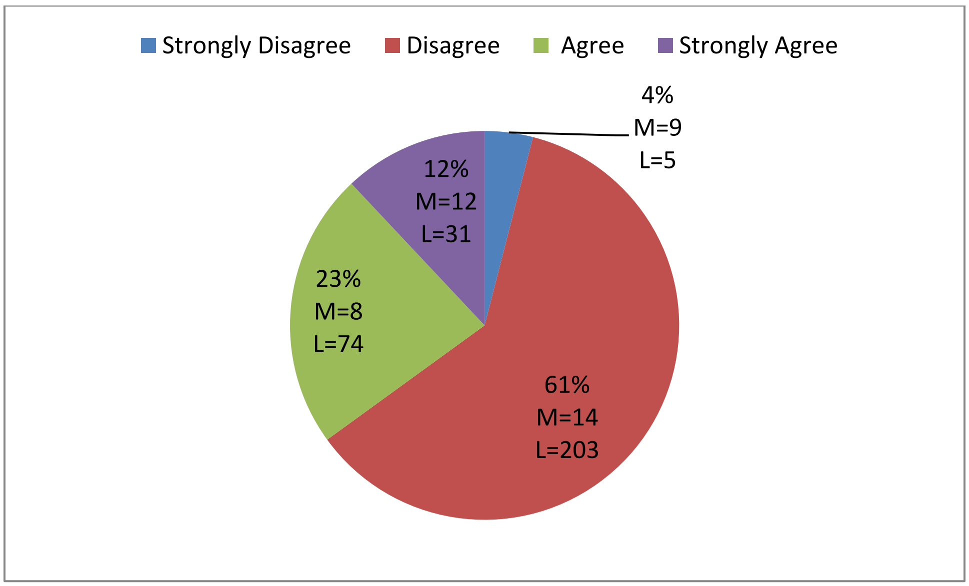


Z value=2.731 ,   P value=0.006

Figure 49: Audit and inspection are conducted effectively.

Fig. 49 depicts how majority of the respondents (47%) believe they have an effective audit system at their facilities thus indicating a positive procedural safety of oil and gas construction in UAE. However, as Fig. 42 shows, there is a concern about the integrity of the risk assessment which can mar the audit and inspection methodology, as pointed out by Lund & Aarø (2004).

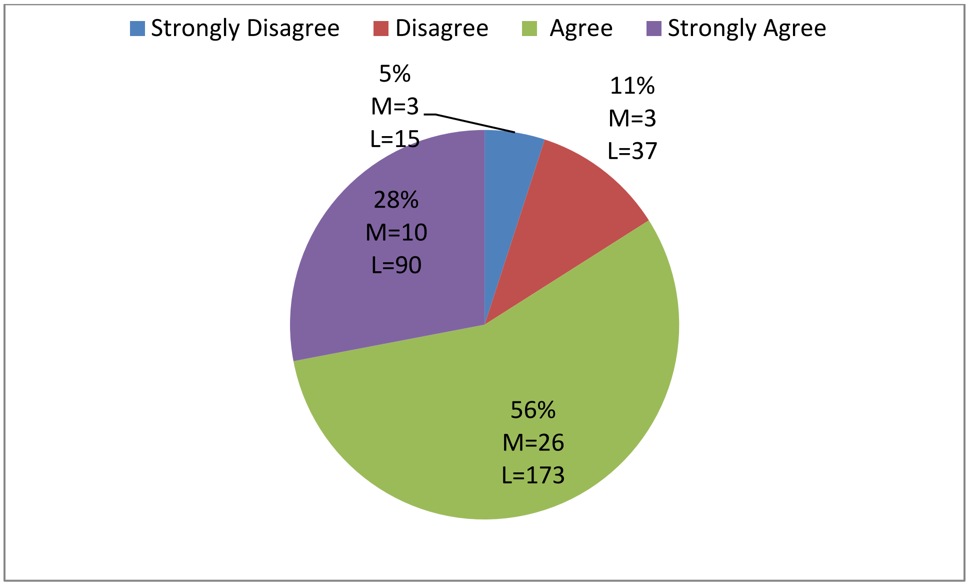
Following this, the questionnaire focuses on the technical safety at the construction site in which equipment safety takes an essential part of the operation safety at the construction sites. Cann et al., (2003) expound that to ensure operation safety in construction activities, there are three important aspects that should be covered in construction: reliability, availability, maintainability. The author explains that these elements aid construction inspectors in evaluating the equipment safety for current and future instances, which will improve the implementation of safety system on a long-term basis. For example, the authors add that during the risk assessment stage all the reliability insurance tests and maintenance records of construction equipment should be studied. This will prevent any fatigue failure that may occur due to over usage at the construction site. Moreover, the authors suggest all reliability records, especially of the heavy static and mobile equipment used at the field, should be made available along with the safety construction engineer to implement the risk assessment effectively. Fig. 50 shows that most employees disagree about the safety equipment safety at the construction site where 61% of the respondents hold managerial posts. This raises the question about the asset management role in implementing the safety system in their construction organizations.



Z value=1.793, P value=0.073

Figure 50: Equipment that is used in construction fields are safety inspected.

According to Sutton (2014) project management skills are as important as technical safety skills in implementing the safety system as it plays a critical role in distributing the resources in the whole construction phases. The author explains that inadequate resources allocation in all construction project designing phases, concept selection, process design and final design will lead to safety implementation disputes in the project execution phases. The author believes that in the designing phases, all major hazards should be examined as a lack of resources preparation, i.e. allocation of safety machinery equipment, could cause accidents at the project sites at the construction, operation stage or both.

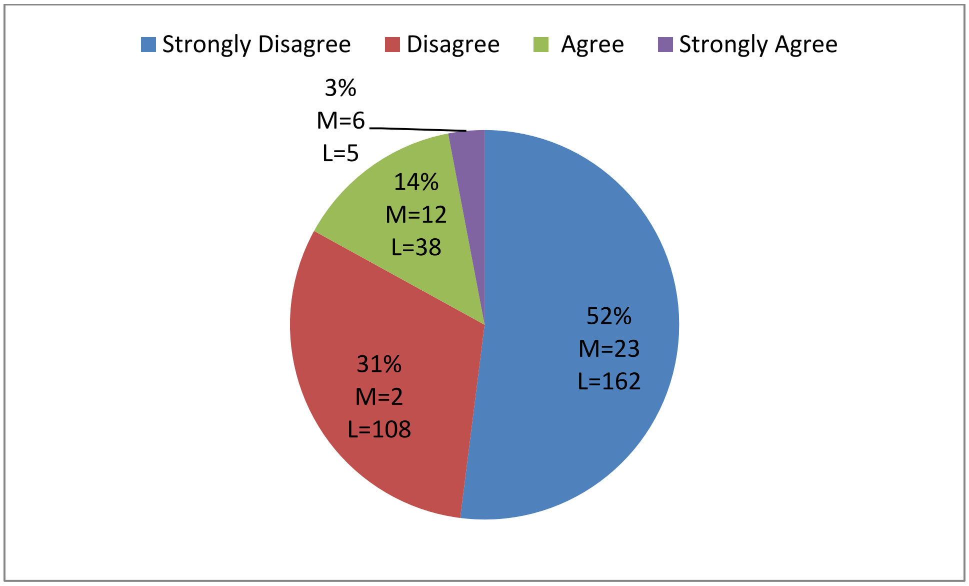


Z value=0.281 , P value=0.779

Figure 51: your Company's uses sufficient resources to ensure safety during construction.

Fig. 51 displays that 56% of employees agree that management use sufficient resources in the organization construction project. The agreed respondents are predominantly manager as well as senior and end user engineers. According to Burt et al. (2004) this may be a logical response from their side since resources allocation is one of the core elements in the managerial and leadership skills. Thus, senior staff may not wish to expose any faults in it. However, in the same question, there is an unusually high percentage, chiefly construction workers, who strongly disagree that resources are used to maintain safety. This raises a serious safety concern that is echoed by the authors earlier.

The survey then asks the respondents about the procedural controls and the disciplinary systems against safety violations that exist in their construction firms. Molenaar & Washington (2009) hold that the presence of the disciplinary is vital in the workplace, but using it incorrectly can be counter-productive towards the safety system. That is, many industrial companies employ an aggressive disciplinary system via salary dedication, blaming culture, and revoking annual bonus. Instead, Molenaar & Washington argue, the industrial management should use a coaching culture as their first choice because the purpose of the disciplinary system is to learn and teach above all else.



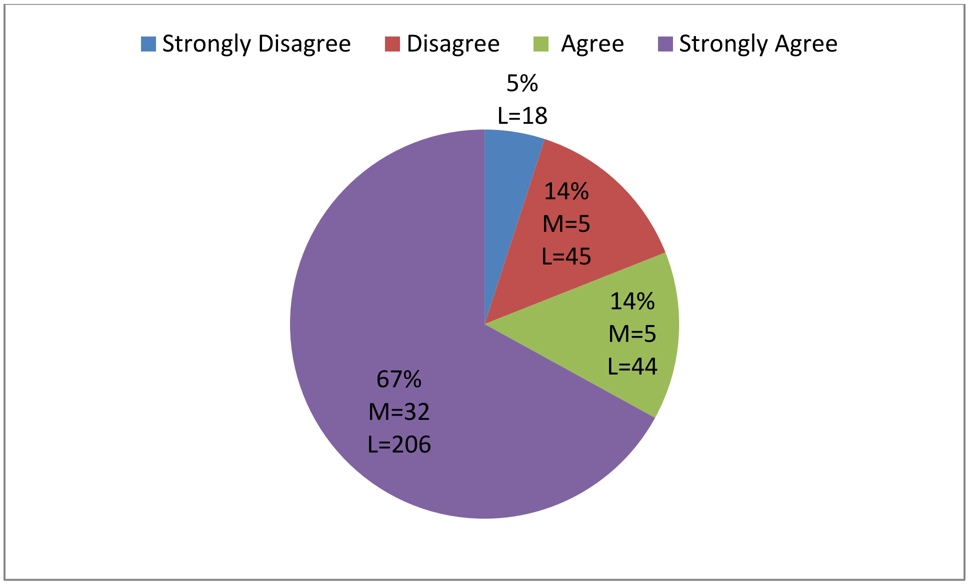
Z value=4.697 , P value=0

Figure 52: Your Company takes disciplinary actions against people violating policies and safety procedures.

Fig. 52 presents the serious organizational gap in the implementation of the disciplinary system, where 52% of all employees strongly disagree with the disciplinary enforcement in their organization. Fang and Wong (2006) claim that weak implementation of disciplinary enforcement impacts other safety system implementation in construction such as risk assessment.

The questionnaire then focuses on the safety practices that should take place at the construction site. According to the Fang and Wong that construction site safety practices play a critical role in sustaining the workers safety where mainly it can be performed through physical and organizational phases. Gillen et al. (2002) explain that the physical practices can involve a variety of actions such as daily site inspection and regular supervision. The authors provide several examples of safety schemes that can be applied at the construction site, such as the PTW system.

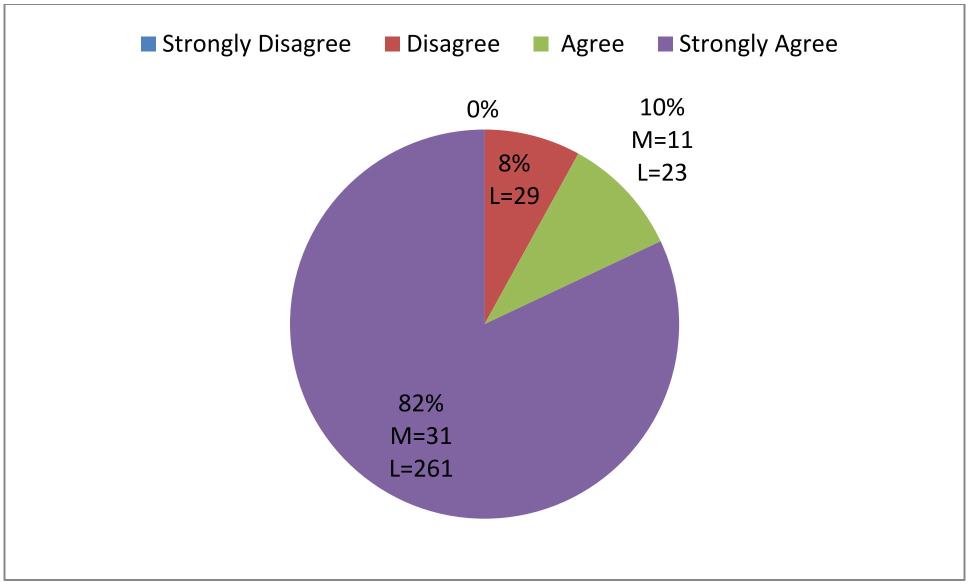
Fig. 53 maps out the strong agreement (67%) between all the respondents that there is a daily supervision practice at the construction site, which indicates the high site safety awareness level amongst construction site workers. This is because construction site workers are directly exposed to the hazards thus making them conscious of and more recipients to the importance of site safety, as opposed to the office employees in the same organization.



Z value=1.270 , P value=0.204

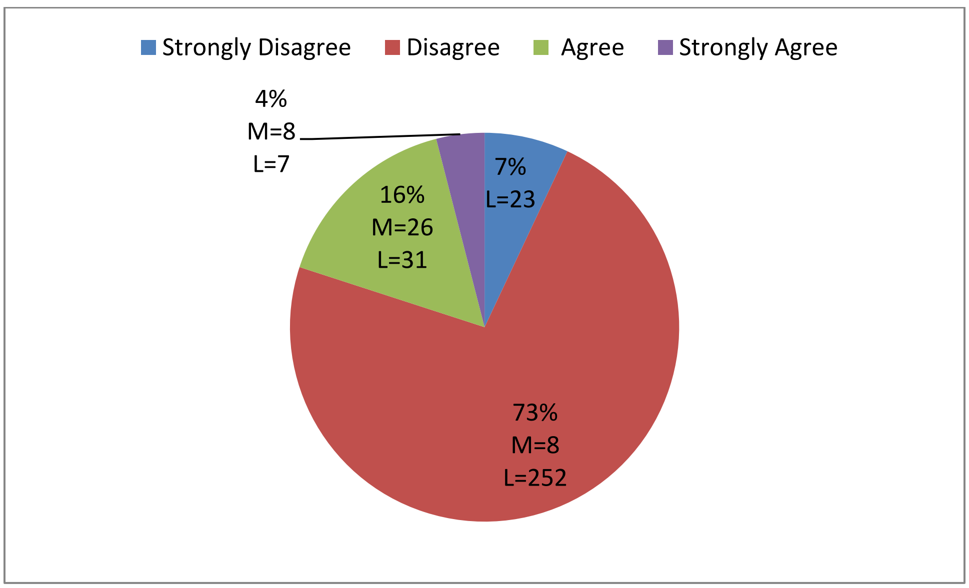
Figure 53: Field Safety supervision is conducted regularly.

Unsurprisingly, a similarly strong agreement was shown in the next question. Fig. 54 shows how 82% of the employees strongly agree about the usage of the PTW system at the construction site. This confirms the point raised by Gillen et al. (2002) regarding the high safety awareness of the construction site workers towards the site safety practices, physical and organizational. In addition, DeJoy (2005) believes that PTW system can ensure a safe environment for all site activities while also monitoring the labourers practices. It can also mitigate any gap that may arise in the initial process of implementing the safety engineering system.



Z value = 2.050, P value=0.039

Figure 54: PTW system is always applied before the start of any job in the field.

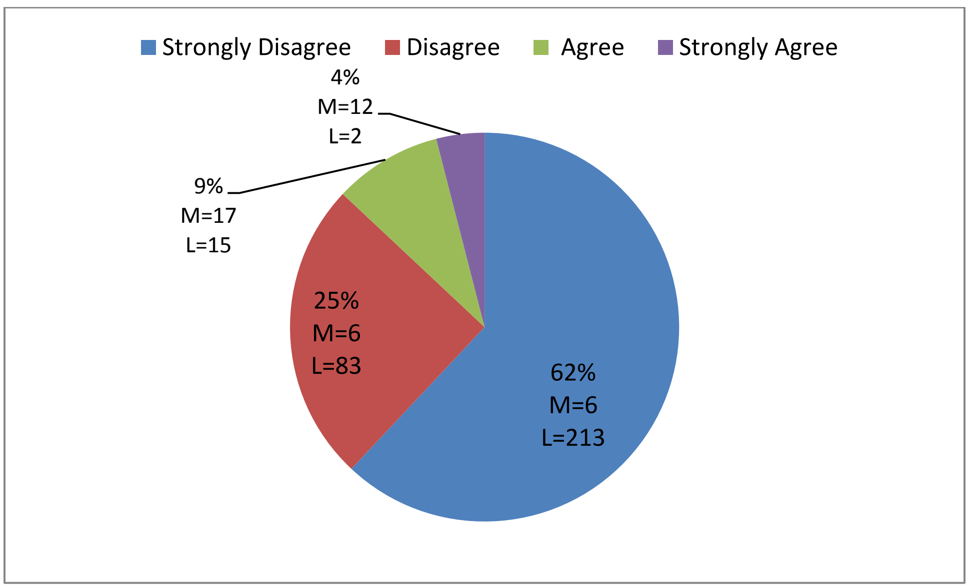


Z value=10.413 , P value=0

Figure 55: your Company's safety management applies continuous improvement concept.

Many scholars consider safety engineering as a dynamic field that needs to be updated from all its different features to maintain efficiency and quality. However, Granerud and Rocha (2011) expound that there are organizational challenges when it comes for applying continuous improvement of health and safety concept in construction. The authors illustrate how most construction firms tend to not use alternative safety methodologies in their construction activities. Furthermore, the writers hold that the resistance of change can be dictated from two employee categories: managers and experienced labourers. In both cases, there is an aversion towards adopting new safety techniques if the firm has been following the same safety controls for a long time. In addition, the authors highlight that continuous improvement process may add extra costs to the organization in terms of providing new training courses for their employees to get used to the new safety approaches.

Unfortunately, Fig. 55 displays that 62% of the respondents strongly disagree about the usage of construction improvement process in the company safety scheme. This may referrer to failure on part of the management as they are the main influence towards implementation of safety engineering system. According to Beatham et al. (2004), most construction companies avoid applying construction improvement process because they have performance safety mentality that focuses only on the current status without planning for future safety needs in construction.

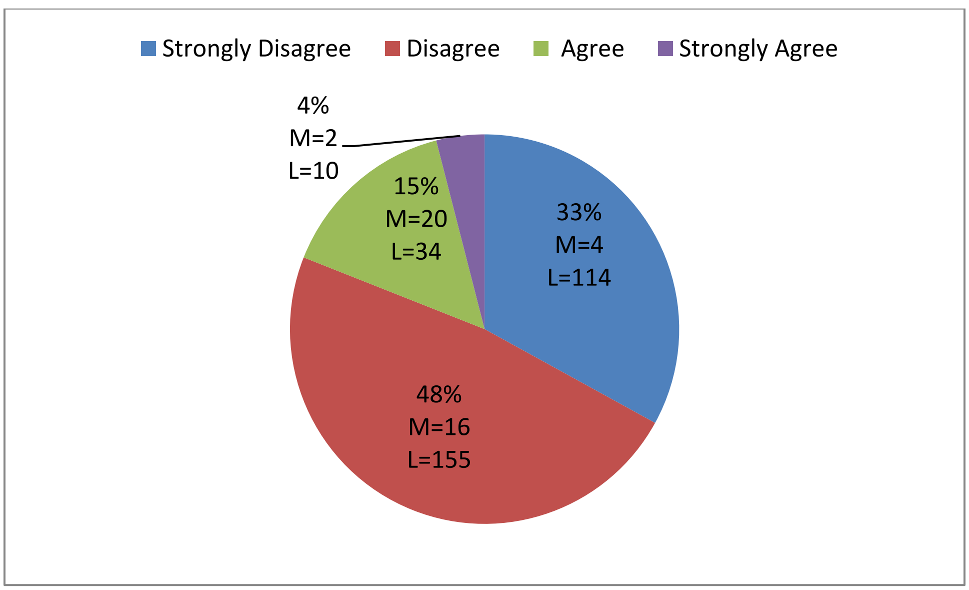


Z value=11.200 , P value=0

Figure 56: There is a strong safety culture between the employees in the construction site.

Ely & Meyerson (2010) mention that safety culture between the labourers at the construction oil platforms can be considered a product of the interaction between organizational behavioural and employees' technical skills as they combine psychological and situational variables. To illustrate, visible leadership of the management positively influence the safety culture between the workers at the construction sites. Moreover, a lack of the welfare facilities and services, such as poor housing and catering, will mar the safety performance of the construction workers. Fig. 56 presents a strong disagreement about the presence of safety culture at the construction sites, with only 4% of the respondents claiming that they have a strong safety culture in their sites.

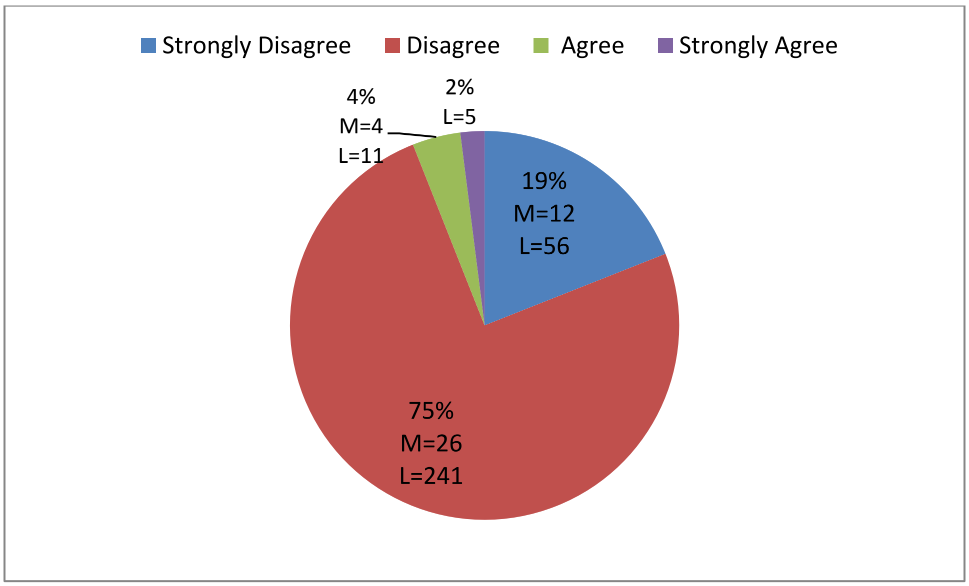
These shocking results raise a variety of questions behind the factors that cause this absence of the safety culture. More importantly, they demand a solution mechanism that should be applied to resolve this major challenge towards the safety system implementation. One way to counteract such dismal results has been discussed earlier in Fig. 33. That is, management must show high visibility at the oil and gas construction rigs, which would systematically increase the safety awareness in the crew members. We should also note that Ely & Meyerson (2010) highlight potential external factors, i.e. welfare and human factors that disturb the adoption of safety culture at the construction site. Fig. 56 display general challenges in the implementing safety culture that require a focused investigation to identify and solve.



Z value=5.994 , P value=0

Figure 57: Coaching culture is used in the construction sites.

Next, the questionnaire inquiries about the practices that shape the safety culture in the work place. According to Kines et al. (2010) the analogy of communication plays an important role in enforcing the safety behaviour at the construction sites. The authors illustrate that although many construction organizations do not have coaching techniques or models in their procedures, senior and supervisor engineers directly working with labourers can follow these techniques as self-initiative. According to the authors, this helps create an open safety culture that will eventually help increase the level of maturity towards safety implementation between the end-users. Fig. 57 shows how 48% of the respondents, mostly end user staff members; do not recognize the presence of a coaching culture at the construction site. On the flip side, 33% of the respondents, predominantly holding management roles, believe that a coaching culture is practicing in their organization. As Kine et al. (2010) points out, the views of employees who spend more time at the construction site, e.g. supervisors and engineers, provide a more accurate reflection of the safety culture. As such, this gulf between the safety culture viewpoints of employees can be attributed to poor communication.

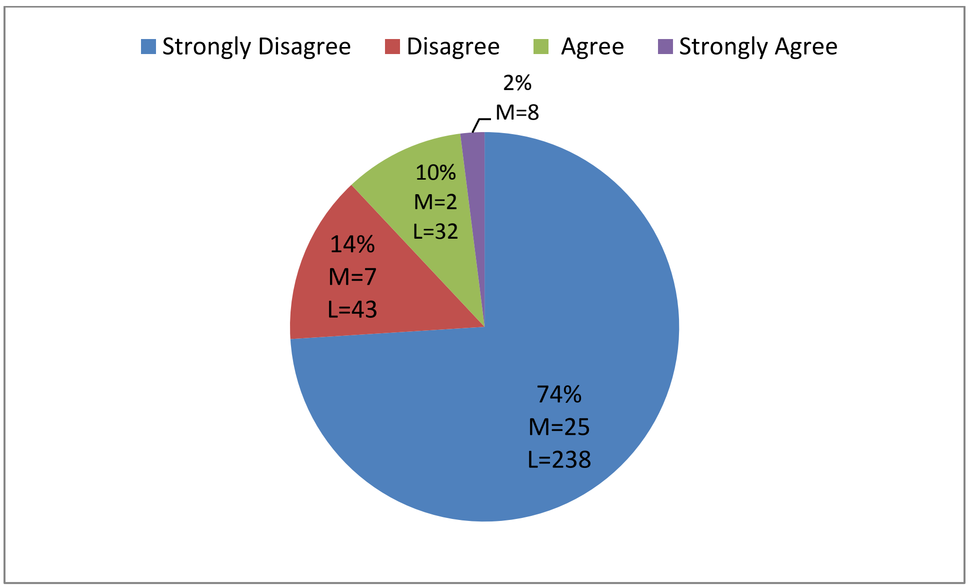


Z value=1.164 , P value=0.246

Figure 58: Behavioral safety activities are comprehensive and effective.

Focusing on the individual level, the questionnaire starts highlighting the commitment of the construction organizations to raise behaviour safety awareness via campaigns or other activities. According to Mearns and Yule (2009) many of the oil and gas firms conduct different safety and environmental activities that focus only on the technical and procedural aspects (maintenance and emergency workshops) without embracing behavioural based safety (BBS). The results in Fig. 58 mirror the authors' statement where 75% of the respondents, from all employee categories, disagree about the occurrence of safety behavioural awareness. The authors claim that the absence of such activities directly impacts the safety engineering system at the construction site.

Choudhry (2014) presents a paper that strives to measure the safety behaviour at the construction site environment through behaviour management approaches designed by the author. Choudhry holds that most construction companies show compliance in the beginning of the experiment but later, gaps and failures arise due to several factors in the monitoring stage. These include meeting excessive production targets, tight construction schedule and a lack of professional skills. Interestingly, at the individual level, the safety behaviour of the construction workers also declines. The author provides an example of not using Personal Protective Equipment (PPE) continuously at the construction site during work time. This shows how the safety organizational leadership can influence the employee safety behaviour. Fig 59 sheds light on the strong agreement amongst the respondents (74% strongly disagree, & 14% disagree) in regard to the absence of the monitoring of the BBS at the construction firms.

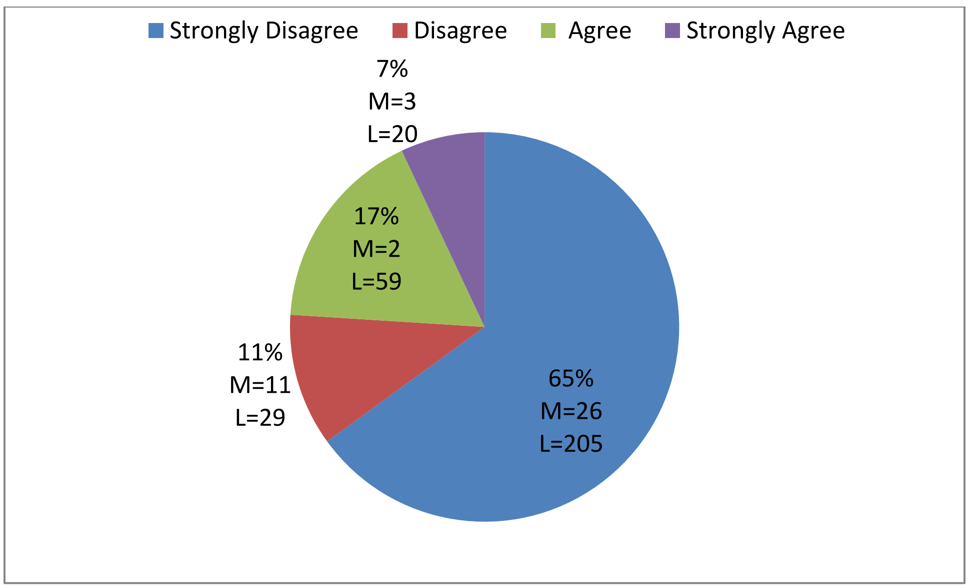


Z value=2.559 , P value=0.010

Figure 59: The management measures and monitors the Behavioral Based Safety (BBS) in construction sites.

This is a serious indication of the vulnerability of the current BBS programme for the most construction organizations (owners and contractors). Although many of the oil and gas construction companies have a BBS programme in their safety engineering system, several factors such as weak monitoring and measuring KPIs can hinder the capability of BBS scheme at the construction site.

Neal and Griffin (2006) believe that the safety culture can be enhanced comprehensively by involving all categories of the employees, especially the end-users in the safety meetings, strategic plans and committees. For example, the authors mention how most industry organizations do not have a safety committee whose main function is to link the site crew with the office team so as to help clarify all workplace safety challenges. As shown in Fig. 60, 65% of the respondents in this questionnaire, particularly the end user staff members, strongly disagree with the work involvement levels in their organization for general safety concerns. This elimination of the end-users impacts the implementation practise of the safety engineering system due to a lack of the integrated visualization (Vinodkumar, & Bhasi, 2010).

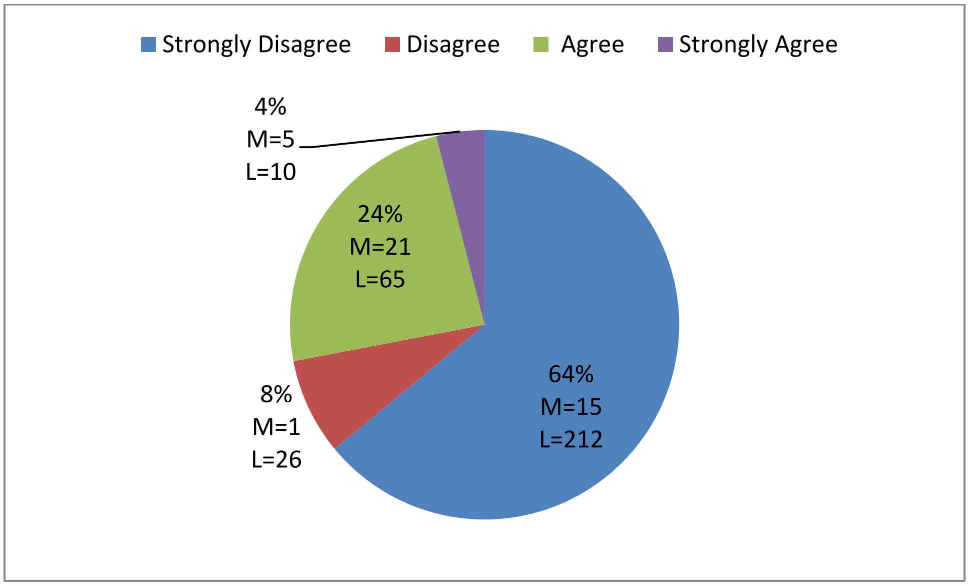


Z value=-1.909 , P value=0.056

Figure 60: Construction worker are involved in safety committees and planning.

Safety responsibility in construction is so critical where many senior staff in oil and gas try to avoid taking or even sharing it. This is due to the legal consequences that may occur after any potential accident. Behm (2005) mentions that avoiding the safety responsibilities is the main reason why many construction employees do not implement the safety engineering system. The author believes that safety responsibility should be defined in the early stages of the construction project, especially the design stages where it can be applied via different. For example, during the hazard identification process, the author suggests to specifically mention the safety responsibility for each potential hazard that may cause accidents at the construction sites.

Moreover, Behm claims that declaring safety responsibility at the construction project helps the safety professionals in their root cause analysis i.e. following the chain of actions and interviewing people will be more accurate and precise.

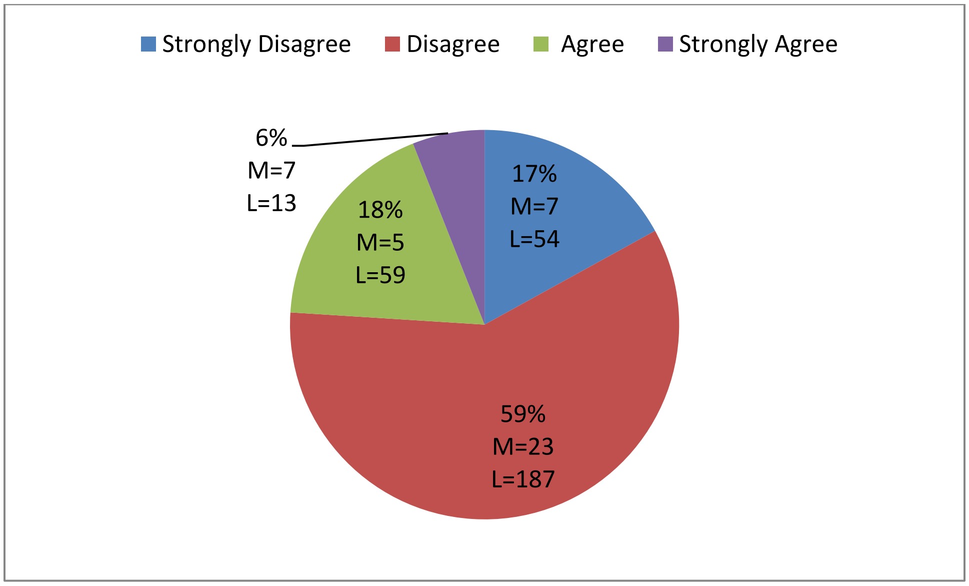


Z value=5.117 , P value=0

Figure 61: Top management actively involved and take direct responsibility of safety incidents.

Fig. 61 shows that 64% of the respondents believe that their management does not take any direct safety responsibility in the case of an incident at the construction site. This produces the feeling of lack of support from management towards the end-user workers. The 24% who hold a contradictory view are placed in managerial positions, thus exposing another major gap between the management and workers in the oil and gas construction. Korman (1999) says that the absence of management responsibility to safety accidents will mar the worker safety performance and may encourage them to practice unhealthy acts, such as not reporting accidents.

Thevendran & Mawdesley, (2004) conduct an experiment that try to examine how construction organizations in critical industries such as oil and gas perceive human factors in their projects. The authors believe that evolution of human factors for construction project is crucial and there is a generic acknowledgement that human factors are the most important elements that can ensure the success and safety of construction activities. The exploratory study of their research show that there are many influences that can impact the interaction between the human and machines and this can cause deterioration for safety performance and increase the frequency of risk at the construction site.



Z value=0.797 , P value=0.423

Figure 62: Human factors are always considered in the hazard identification stage.

The authors explain that these influences arise from different sources inside the construction firm, including management leadership, mind-set and education/training. For instance, if the organizations share the ownership with the employees or hire a welfare officer, it will increase the sense of belonging and that will help to reduce the potential existence of human factors risk in the site. Fig. 62 sheds that most respondents (59%) do not agree that their construction firms are examining human factors in the hazard identification analysis which can impact the efficiency of risk assessment. Haslam et al., (2005) believe that many of construction projects in high risk industry such as oil and gas do not involve assessing human factors in the early stage of the risk assessment which affect the implementation of the safety engineering system.

Finally, the questionnaire asks the respondents two questions about the factors that can improve the safety engineering system inside oil and gas organizations. Usually the safety engineer system comprises of areas such as leadership, audits, regulations, planning and risk assessment. Fig. 63 shows that most respondents point to this risk assessment methods (46%) and Behavioural Base Safety Programme (33%) as the top areas that needed to improve, a result that is consistent with the survey results. To illustrate this point, the questionnaire outcomes reveal the willingness of safety commitment in the oil and gas construction platform from the management level to the end users level, but external and internal factors inhibit its implementation. The same concept is reflected in regard to the BBS based on the respondent's answers at the end of the survey where a glaring ignorance towards BBS factors such as Human Factors (HF) and their role at safety engineering system implementation is highlighted.

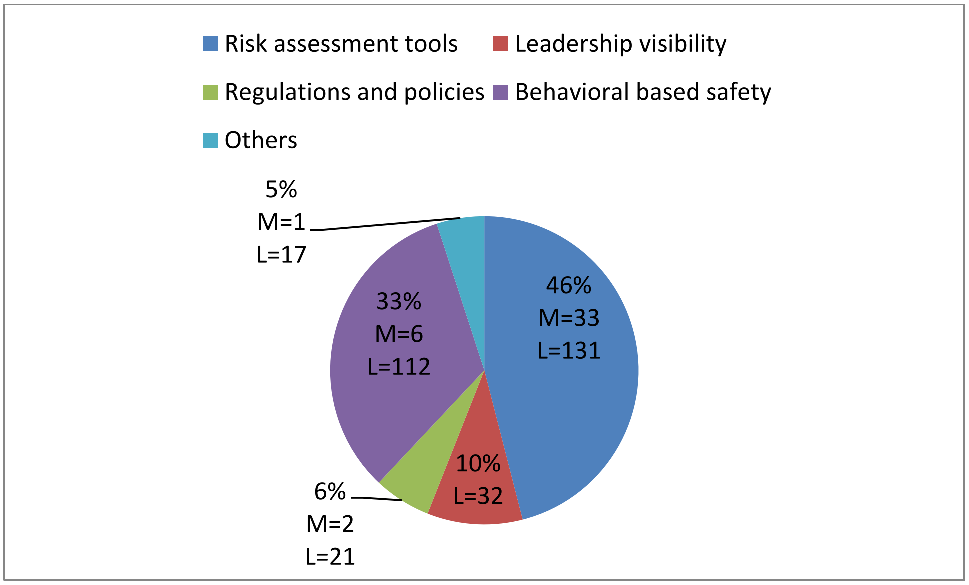


Figure 63: Which area of safety engineering system in your company requires improvement.

The last question in the survey asks the employees about the most effective factor that can impact the mechanism of the safety engineering system for oil and gas construction industry. Here, poor decision-making was selected by 45% from the respondents. Koller (2005) mentions that factors such as poor communication, lack of sufficient and integrated examination will result in a weak risk assessment output that decision-maker will depends on. According to the author, this is why many of construction professionals in oil and gas industry consider poor decision-making is the real root cause for most incidents that occur in the site as shown in Fig. 64.

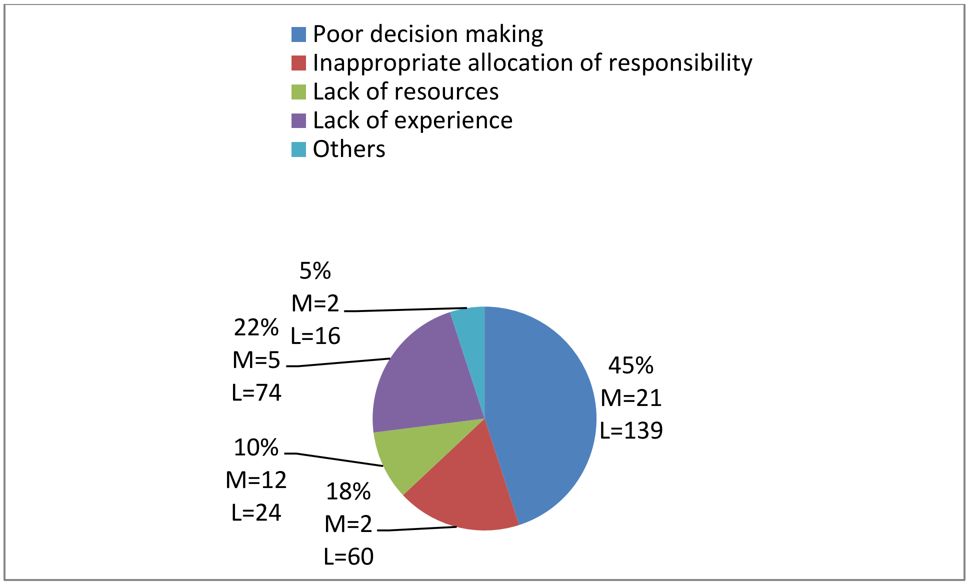


Figure 64: which one from the following factors could be the most effective one in the safety engineering system implementation.

4.4. Summary of the chapter

The majority of the questionnaire respondents range between 20-50 years old, and work with owners and contractors' companies at the oil and gas construction field. Most respondents possess a college education, but this depends mainly on the position they hold at the construction firm. The outputs of the survey explicate several positive and negative aspects regarding the implementation process of safety engineering system that are practiced at the construction sites. Many responses indicate the existence of positive and negative practices, such as visible leadership in construction site and strong theoretical HSE MS that is in the place among the company producers. For example, Fig. 28 depicts how most employees believe that they have strong HSE MS document. Yet, simultaneously, as can be seen by Fig. 35 and Fig. 36, many of the safety procedures need to be updated to compel workers into implementing the safety practices.

In addition, the outcomes of the survey highlight, as Fig. 42 reflects, a major weakness in implementation of risk assessment which raises many questions: why do most employee believe so, especially the construction workers? How can construction companies improve the application of risk assessment to enhance the implementation of safety engineering system?

Avoiding these questions will impact the safety decision-making mechanism, as expressed by the respondents in Fig. 43. This sheds light on the importance of having a strong monitoring of the risk assessment mechanism to ensure the safety environment in the workplace.

Aside from the procedural gaps shown in the questionnaire results, there are some technical safety concerns towards the equipment safety at the construction sites. For example, Fig. 50 shows that most respondents do not think that all the equipment is inspected at the construction rig site, something that should absolutely not be the case if technical safety scheme is implemented. Moreover, since there are enough resources that can be utilized for safety purposes, as shown in Fig. 48, such negative perspectives towards technical equipment safety should not be so prevalent. In fact, they shouldn't exist at all.

The gap between management and end-users is obvious from this questionnaire. These gaps become even more pronounced when the questionnaire examines the behavioural safety aspect at the construction activities. This is critical because even if all potential procedural and technical hazards are assessed without considering the behavioural safety factors, it will not be effective to simply guarantee the integrated safety at the site. For instance, according to Dey (2004), human factors play a root cause in most major incidents during oil and gas construction. As such, it is vital to analyze human factors during risk assessment stage. This goes against the findings of Fig. 62, where there is a complete agreement over the absence of the human factors in the early stage of risk assessment. This can be seen as one of the main reasons why employees feel that they do not have a strong safety culture, as indicated by Fig. 56.

This questionnaire exposes several areas that directly influence the safety engineering systems, especially the risk assessment, varying from technical, procedural, and behavioural features. However, further investigation is necessary to understand the reasons and risk factors behind why these challenges exist inside the construction organization, particularly between senior management and labourers. Such an investigation will help reach the aim of this study i.e. providing an integrated framework to optimize the safety engineering system in the oil and gas industry. This can be approached through interviewing construction professionals who possess a complete view pertaining to the current barriers and issues for safety implementation at the construction sites. This will be presented next in Chapter 5 of this research.

Chapter 5: The Interviews

5.1. Introduction

The main goal of the conducting the interviews is to identity the causes for the numbers and responses that appeared in the questionnaires which require further explanation and analysis. There were four safety challenges discussed from two perspectives, managers and workers, where both interviewees had the same questions. The questionnaire highlighted major gaps in the behavioural safety either at the individual/group level thus affecting the whole safety culture in rig construction site. This will enable the interviewee to search for the causes which will then be discussed with interviewees. More emphasis will be put on this section due to the inordinate response in the survey pointing out at an absence of behavioural safety, which, according to the literature review, led to many famous construction accidents. Lastly, safety of the construction equipment will be analysed as part of the technical safety and how it is addressed in the risk assessment in the site. This will include the maintenance system inventory and current best practices that ensure the safety calibration and performance of the equipment that would grantee their reliability, availability, maintainability and safety (RAMS).

5.2. The interviews

- **First Interview**

The interview was conducted in the National Petroleum Construction Company (NPCC) head office, which is considered a major oil and gas construction organization in UAE. It has many construction projects with a variety of government oil and gas companies e.g. Abu Dhabi National Oil Companies (ADNOC) in different areas of the hydrocarbons upstream projects. The company profile indicates that there is a diverse culture among employees, with more than 60 nationalities and more than 20 international subcontractors firms (NPCC, 2014).

The interview starts with demographic questions to understand background, experience and the current status of the interviewee in his construction organization. The interviewee was a male in his mid-forties and works as a construction manager for a number of offshore and onshore rigs. He has more than 25 years' experience in the oil and gas construction, with 10 of them spent at construction sites as a technician, project coordinator, supervisor and engineer. This variety of roles is one of the reasons he was selected for the interview as he would provide a layered view on developing the integrated framework. At the end of this section the interviewee was shown the results of the first questionnaire conducted in this research.

In the second section of the interview, the interviewee was asked why most respondents believe that risk assessment is the weakest element in the safety engineering system either in the clients or contractors companies. The interviewee illustrated how this reflected one of the main challenges existing in the Middle East for a long time. From management point of view, the interviewee believed that the major obstacle to risk assessment it being treated as a documentation process rather than an effective method for ensuring safety of the employees. As such, most risk assessment meeting are held inside offices and only "tool box talks" are conducted at the construction site thereby affecting the steadiness of risk assessment implementation. This often arises due to many senior management staff falsely believing that tool box talks can replace the role of the risk assessment. The interviewee explains that the core of the tool box talk is highly depended on the recommendation of the risk assessment. Thus, if any defects appear in it, such as lack of attention, this will lead to a chain of failures in the reset of the safety process.

According to the interviewee, many construction firms also fail to consider how risk assessment is a vital method that should be updated at all times for a task. For instance, the interviewee suggests that risk assessment documents should be updated frequently and reviewed by all concerned parties, from management to end-users staff. According to him, this approach is not practiced by most organizations in the Middle East. Instead, they rely on the first examination of the risk assessment in the office based, where this issue can be overcome by dedicating a special risk assessment committee. This committee can enhance the risk assessment mechanism via several activities such as involving the end-users in the preliminary phases of the risk assessment and distributing the roles of the risk assessment implementation plan. Finally the interviewee agrees that the current practices of risk assessment fail to involve all areas susceptible to hazards i.e. organizational and behavioural. Most construction managers in the oil and gas industry focus on reactive technical defects that may take place in the construction operation stages.

Procedural challenges, the third section of the interview, discusses the questionnaire response regarding the procedures safety performance and why so many respondents believe that their company safety procedural are not updated and not understood by employees, particularly construction workers. The interviewee mentions that many construction organizations invest heavily into the safety procedures and keep them updated until they earn the qualification from The International Organization for Standardization (ISO) certifications to enhance the company's marketing reputation. However, following this, organizations begin procrastinating in regards to safety procedures and only review them until the next ISO audit cycle. The key point of using the safety procedures is to provide a robust documentation system that establishes a safety culture in the organization and safeguards the workers' wellbeing. The interviewee claimed that this is the correct mindset that should be followed with procedural safety that eventually will lead different ISO certifications. Additionally, most oil and gas construction provide new employees with only one introduction about all the safety procedures available in the organization. However, there will be no courses about the safety procedures and the suggested methodology of using them later in the employee career thereby marring the safety value of the procedures. Moreover the interviewee linked the weakness of risk assessment implementation with the low enforcement of safety procedural requirements at the construction sites. That is, many safety barriers are ignored due the lack of commitment to the organization's safety scheme. For example, it is rare to have a risk assessment evaluation sheet that involves safety procedural clauses where this practice can enhance the employee safety awareness towards the safety procedures and standards enforcement inside the firm. Lastly, the interviewee mentioned that there should be a specific committee responsible for examining the implementation and updating the safety procedures inside the organization via several techniques such as auditing and benchmarking.

Since there was a major gap in the safety culture between the employees (as the responses in the questionnaire displayed), it is vital to focus during the interviews on the root causes of an unsafe attitude. According to the interviewee, behavioural safety and human factors did not arise in the construction safety landscape until the early of the 1990s. It was after this that construction professionals became aware of the critical role of the behavioural safety in preventing injuries during construction. However, the interviewee elaborates that in any construction incident on the oil and gas rig, the presence of human factor acts as a root cause. This highlights the importance of having safety culture inside the workplace, especially the end-users who are exposed to hazards.

The main issue with the behavioural safety is that management often fail to understand how to apply BBS programme and how can one strengthen the risk assessment with it. For example, HSE construction engineers tend to conduct numerous safety workshops and campaigns that foster individual safety. Unfortunately, these practices alone are not enough to establish healthy safety culture. The interviewee suggests that having healthy safety culture needs more practices and supporting system that can cultivate a safety climate amongst workers and encourage them to implement safety prior to any job. This can be achieved by having an open reporting system to help employees report and document all unsafe practices, near misses, and accidents without fearing any disciplinary action. The interviewee reports witnessing many cases where employees try to hide safety accidents to avoid being penalized, particularly those that may affect bonus or performance evaluation. As such, associating safety with job performance in this manner often leads to gaps in the BBS programme implementation. Thus, it is crucial to distinguish between the individual's performance and incident reporting to nurture a safety culture in the workplace. Not only does it foster a healthy reporting system inside the organization but also helps identify more hidden hazards in the identification stage.

Moreover, the oil and gas construction field is not a very stable area given its close ties to the crude oil market. As oil barrel prices decrease many of contractor's construction companies begin downsizing, a process chiefly affecting the end-users. Thus, there is job security issues for construction workers and often reflects in their performance at the construction site. To avoid that, the interviewee suggests that suitable welfare plans should be associated with each employment contract to cushion the blow to their economic struggles.

Finally in this section, the interviewee illustrates that weak monitoring of behavioural safety inside the workplace is another safety obstacles which affects the risk assessment implementation. Current monitoring practices simply fail to provide realistic solutions. For instance, many Middle Eastern construction companies use the stop card system that allow workers to stop any employee involved in any accident prone situation, regardless of hierarchy.

This is generally considered an effective behavioural monitoring scheme. According to the interviewee, however, this system is not without its shortcomings since it is reactive system that often leads to temporary outcomes. The interviewee explained that coaching sessions are usually used after accidents or near misses. The entire focus is to eliminate the immediate causes without delving into the root causes of these human errors. Such a myopic approach adversely impacts the risk assessment implementation because a successful risk evaluation requires an integrated review for all human factors. The interviewee also points out that a lack of safety motivation in the construction organizations is the reason behind this reactive mentality towards the behavioural safety. To avoid this, a safety motivation should be in the BBS programme as one of the main element designed to assist end-users through all potential barriers that contribute to human error, i.e. poor education, language difficulty, and work load. For example, the monitoring indicators should also be able to focus on the positive side of behavioural safety where construction firms should reward the employee displaying positive behaviour at the construction site. An example of such behaviour is translating the safety sign borders for the labourers who have difficulty understanding them.

Equipment safety is the last part of the interview pertaining to the technical safety. The interviewee believes that the oil and gas construction industry hypothetically has a highly technical safety standard due to the risky work environment. For example, aside from falling and dropping objects, there are also hydrocarbon materials that pose as severe hazards. Moreover, most sites are located in remote areas and it is essential to check the whole technical safety features for all transportation vehicles. The interviewee mentions that the required recourses are provided to ensure the technical safety in the site, but the inadequate competence and knowledge is the major challenge that needs to be analysed during the risk assessment. According to the interview that, this is why in the questionnaire many respondents highlight the safety issue in the equipment where the real hazard and threat here is not only consists of equipment failure but, also handling and using the equipment in the right and safe manner. Many construction organizations do not emphasis in the handling equipment competence especially for the end-users in which most of construction firms are conducting their equipment training in the workplace for short period of time. The interviewee adds that, it not very frequent to see labourer who has certification from a third party that ensure the technical competence of this worker with certain equipment, e.g. jacking up rigs.

On the other hand, the interviewee posited that reliability and maintainability of the construction equipment should be evaluated during the risk assessment process. He believes most organizations have major safety defects in these two areas. When a contractor or a client company orders the equipment from the vendor, a maintenance schedule will be available that explains how and when the equipment needs to be checked or calibrated. It also recommends several firms in-charge of these activities. Additionally, due to cost reduction and time saving, many construction companies try to overuse the life span of the equipment and conduct a minimal maintenance programme. For example, the interviewee explicates that it is very rare to see reliability testing scheme for equipment supervised and designed by the safety department. This reflects one of the technical gaps between them and maintenance department, leading to potential equipment failure mode. Unfortunately, most construction companies consider reliability of the equipment as a responsibility of the maintenance team. There is also a separate safety evaluation conducted without involving the HSE team in the same organization. Thus, for them, there is no need for integrating another team into the matter. This misunderstanding is the reason why this industry needs to have a more integrated mind-set about the safety implementation in the construction companies. The interviewee illustrates that upon realizing this, some construction companies recently launched the Reliability, Availability, Maintainability, and Safety (RAMS) system which is an initiative aimed towards enhancing the equipment safety performance.

At the end of the interview, the interviewee was asked if he wished to make any further comments or give suggestions about the current safety challenges in the oil and gas construction field. He stressed the two following points: involvement and integration. Safety is not the responsibility for one department or the top management or the end-users only. It is state of working that everyone in the organization can contribute to regardless of position and qualification. The involvement of variety of skills and views helps integrating a view that optimizes the implementation process of the safety engineering system.

- **Second Interview**

The second interview was conducted in an offshore construction site at Upper Zakum offshore oil field development. It is considered the fourth offshore oil field in the world, under the authority of Zakum Development Company (ZADCO) government sector (ZADCO, 2010).

The first major construction project was executed by NPCC pertaining to the installation phase of the field which includes a variety of materials and activities such as jackets, riser platforms, flare towers and fibre-optic cables. Following this, the construction projects are a development focused that constrain with the field expansion and increase the production with many international construction firms involved. For example, Petrofac has many construction projects that deal with providing concrete layers and units to install beach protection for this artificial island.

The interviewee was a male in his early fifties. He has been working in construction activities in the oil field for 25 years. He started off as a construction worker for 10 years and then worked as foreman for 6 years. From 2007 until now, the interviewee has been working as chief supervisor in Petrofac with his main responsibility being ensuring the safety and integrity of workers and the constructions sites. He was selected for this interview on account of him being a former labourer and possessing a vast experience with the workers' cultures, challenges, and mentality.

After the demographic questions, the second section of the interview (risk assessment) began with exploring the reasons why most respondents believe that risk assessment is the weakest element in the safety engineering system. According to the interviewee the first reason is that most workers cannot understand the risk assessment procedures. For example, most risk assessment procedures are written an advanced language that is hard for workers with limited education to understand and utilize in their assigned activities. As such a simplification method is required to deliver the risk assessment concept. There should be a systematic approach to highlight all possible hazards and the proper mitigation plans. Additionally, the interviewee stresses that the major absence of end-users' involvement in the risk assessment meetings is also a major factor. In his view, most construction organizations consider risk assessment a managerial document that only senior staff should contribute to. Most managers further reinforce this misconception by allocating monitoring roles to construction supervisors or foremen who are not involved in the initial stages of the risk assessment. The interviewee posits that this is the key contradiction suffered by risk assessment mechanism implementation in the oil and gas construction projects. At the end of this section, the interviewee agreed on the need for an integrated risk assessment as it provides integration between several vital areas, something he found missing in most of risk assessments in his experience.

The procedural challenges were discussed in the third section of the interview. Here, the interviewee explains several points on how procedures play a vital role in the labourer's safety at the workplace. For instance, he mentions that the procedural challenge for construction workers differs totally from the top management due to the scope of the work. The top management typically work on the safety procedures to enhance the firm's reputation through getting several ISO certifications in order to improve business strategies. Conversely, for workers understanding the safety procedures is a top priority. That is, most oil and gas construction companies provide basic safety courses for end-users such as H_2S safety, fire safety, and first aid that can give the individual labour the essential safety skills to deal with hazards and risks at work. The interviewee believes that these courses are not enough approaches to ignore or restrain from giving the required safety procedures orientation which usually is specified for employees who have higher positions i.e. engineers and team leaders. Understanding the required procedures will allow the end-users to know the core concept behind the safety engineering system and the importance of implementing it in the workplace and this will improve the workers technical and behavioral safety skills regardless of their academic qualifications. To maintain a high level of procedural awareness among the construction workers, the interviewee suggests conducting a yearly refresh course that sheds the major safety procedures and their updates, case studies, and challenges. These proposed ideas can optimize all the methods in the safety engineering system where risk assessment will be handled with a more refined mentality from the construction workers.

In the fourth section of the interview, the quality of safety culture between the end-users was discussed to find an explanation for the negative responses about it in the questionnaires. The interviewee was not surprised by these outcomes in the safety culture or behavioral safety because in his view these numbers reflect the current and previous issues in this industry. Unfortunately, most workers do not see the need of the behavioral safety due to the absence of other social/economic elements in the workplace. For example, the interviewee mentions that welfare is one of the hidden aspects that often lead to hazards that affect the employee safety performance. According to the interviewee, there are two main types of welfare services that the organization should focus on for labourers: physical and mental.

Pertaining to physical welfare aspect, the interviewee holds that many construction companies do not provide proper accommodation for their workers in a short-sighted attempt to save cost, along with poor welfare scheme inside the organization. Individually, the interviewee witnessed many accidents or near misses where the root causes is stress due to inadequate housing. Many construction organizations try to cram workers in accommodation units, especially in offshore projects. Additionally, many facilities such as washing machines, bathrooms, and shower rooms are of substandard quality due to overuse, lack of maintenance, and harsh environment factors. When combined, these factors contribute heavily towards maintaining a safety culture amongst end-users.

Egregiously, mental welfare of laborers is an unfamiliar concept for many managers and senior staff members at construction firms. The designed welfare plan emphasizes the conditional characteristics of workers while eliminating vital features such work loading, social activities, and psychotherapy. According to the interviewee, these elements are critical for implementing safety as the oil and gas construction industry usually operate in remote areas with a divers- international l workforce. Since the majority of the employees at the construction site are end-users, the interactions between them will form the safety culture. This underlines the significance of mental welfare on the safety engineering application.

Next, the interviewee mentions how there is a lack of development plans to further develop construction workers, something that applies for other employees in the organization such as engineers, team leaders and managers. Usually, construction workers receive safety courses in the beginning of their tenure only resulting in them working with the same job routine for years. According to the interviewee, it is thus unsurprising that many end-users lack any motivation when compared to other employees who have development plans that ensure their career growth. Several construction firms justify that the academic level for most labourers in this region do not qualify them to take courses or schemes to advance their career. However, this is not necessarily true according to the interviewee. He explains that there are a variety of courses especially in safety i.e. National Examination Board in Occupational Safety and Health (NEBOSH), which do not necessitate any academic qualification. Unfortunately, organization in the Middle East view end-users of the company as constant production force at the construction site. The interviewee elaborates that this perception should be changed to a new one that deals with the labourers as capital in which one shoould invests in.

In the fifth section of the interview, equipment failure was discussed to identify the root causes of this issue in the oil and gas construction projects. The interviewee explains that this is a challenge faced by many international construction companies, often leading to huge economic loses. However, from his experience, many construction organizations do not understand the reliability culture and its role in sustaining the stability of the asset management. The main purpose of applying reliability with safety engineering system methods i.e. risk assessment, is to assist the facility in reaching dependability levels that ensure the continuity of business and recover from potential equipment faults. For example, the interviewee mentions that many construction mangers request to reduce the Mean Time to Repair (MTTR) of the equipment scheduled for preventive (frequency) maintenance. This action may increase the level of availability of the equipment, but also results in minimizing reliability and maintainability. This adversely affects the safety performance of these methods in the site. The interviewee suggests that in order to enhance the implementation of the risk assessment, the reliability level of the equipment should be pre-emptively recognized in the hazard identification stage to anticipate potential failure that can arise due to equipment failure.

Another critical point that the interviewee addresses is the major conflicts senior staff members have with safety standards of the equipment between the manufacturing and construction phases. For example, for pipeline installation, many accidents occur due to inadequate maintenance plan for the bending and rotary equipment. This arises due to many maintenance engineers relying on the prevention standards that come directly from the vendor without considering the harsh environment factors on-site. Bending and rotary equipment in the offshore construction sites can easily get corroded at an accelerated rate due to wet/dry conditions which usually irritates chain of chemistry reactions.

At the interview's conclusion, the interviewee believes that the questionnaire responses do imitate some of the current safety challenges that the construction industry in the oil and gas field. According to the interviewee, there are safety gaps in all areas in the safety engineering system: technical, procedural, and behavioral, where each one affects the other. This shows the needs for an integrated system to eliminate these defects. However, the interviewee stresses that behavioral element is the most vital factor in controlling and mitigating the hazards for the end-users because it directly emphasizes the human factors of the employees. For example, by implementing the behavioral risk assessment at the construction site, the performance skills of the workers will be evaluated. And in case of occurrences of poor performance, this will help the organization identify whether the roots causes are procedural or technical, and to enhance the safety performance. The final point discussed by the interviewee was that failure in implementing the risk assessment leads to the failure for the whole safety engineering system because this interacts with all other methods continuously during the project timeline. Thus, it is vital for management to involve all different employees in it to provide a landscape perspective for all the potential risks.

5.3. Analyzing interview results

For the first interview, it is noticeable how the interviewee has more information regarding safety engineering system and its application from the theory standpoint. For example, the interviewee explains that the major weakness in risk assessment is that most organizations deal with it as a process which needs to be completed and documented without proper monitoring of its implementations. However, in comparison to the second interviewee, he justifies the difficulty of implementing the risk assessment due to the complex language of the procedures which most workers cannot understand because of their education level. Here, the second interviewee gives a more pragmatic view due to the scope of work. At the same time, both interviewees agree over the importance of the involvement of the construction workers in the risk assessment meetings as a pair of fresh eyes that can help determine all the possible hazards in the job activities. The importance of the hazard identification stage was mentioned as a common point and how it should be integrated to grantee the safety of the construction site without any comprise or replacement. For example, the first interviewee provided an example about how many workers use tool box talk instead of the original hazard identification conducted in the office and this matches the view of the second interviewee about the gap of communication in risk assessment between managers and construction workers.

Interviewees presented different analytic views regarding the procedural challenges in the construction organization. For instance, the first interviewee believes most senior managements work very hard in the safety procedures especially at the beginning of the company establishment to get the international certificates in order to enhance the marketing reputation only to abandon it later on. This assumption can be linked to the second interviewee's view regarding the lack of training for the construction workers towards the safety procedures. For example, continuous focus and attention towards procedural skills is required for the workers as the technical skills. Thus, when a lack of procedural knowledge amongst workers occurs it indicates a weak management. This can be noticed from several practices at the construction site such as the difficulty of labourers to gain access to safety procedures and not referencing the procedures clauses during the risk assessment. These unwanted practices can be replaced by better ones through visible communication. As suggested by the first interviewee, having a specific committee ensures the quality and implementation of the safety procedures. As per the second interviewee, this committee can also supervise the procedures and polices training courses that should be handed out on a yearly basis for the construction workers. Moreover, benchmarking with other construction organizations can be another approach that helps identify the areas that can be modified, as mentioned in Chapter 2.

For the behavioral safety, there were many causes explained by both interviewees. For example, the first interviewee holds that management has a limited understanding about the applications and implementation of safety culture where practices such as blaming attitude and lack of safety can affect the behavioral safety of the employees, especially construction workers. According to Ruchlin et al. (2004) such a vulnerable mentality is related to the organization's safety policy being mistranslated by management. As such, the authors suggest conducting surveys frequently to glean the labourers' satisfaction with the safety culture programmes at the construction site and how it can be improved. This usual interaction between end-users and management would help create a culture with open channels for communication, as echoed by the first interviewee. As a result, proper monitoring for the behavioral safety can be applied to deliver an updated and transparent image of the safety culture and its efficiency at the construction site to the senior management. Both interviewees agree about the critical role of the individual behavioral safety in forming the safety culture where the second interviewee also stresses how poor welfare plan can disturb the safety performance of the worker. Geller (2001) supports the second interviewee's idea claiming that many construction companies do not provide the sufficient welfare services for end-users in the oil and gas rigs. Additionally, the author believes that most human factor incidents are due to the poor mental human welfare plan that should prepare the right condition for the employee to work in safe manner. Geller admits that it is hard for the management to find end-users that apply and implement behavioral safety completely in the workplace, but the author proposes a model that encourages improvement of the safety culture. This can be approached if the management provides self-esteem and a sense of belonging for the workers as the second interviewee mentions. An example of this would be how the second interviewee mentions the necessity of providing development plan that guarantees career growth for construction workers. Implementing behavioral safety also helps optimize risk assessment to be more comprehensive as the interviewees said but the management should start taking the accountability of the safety culture at the construction site.

Equipment safety was the last point to discuss with both interviewees. Equipment failure appears as the major technical issue facing the construction industry in oil and gas. As illustrated by the second interviewee, the gap between the maintenance and safety departments is one of the vital points influencing the integrity of the equipment. RAMS system should also be included into safety engineering system. Furthermore, the first interviewee stresses that safety professionals should distinguish between the safety standards in the operating and manufacturing phases. However, according to the second interviewee, he believes many equipment failures occur due to poor handling skills from the end-users. To expunge such occurrences, the second interviewee suggests refocusing the equipment control training courses for construction workers to make them adept at operating these equipment. Lastly, reviewing audit and inspection reports for the equipment during risk assessment would help determine all aspects of hazards such as equipment materials, safe distance, and machine calibration.

The main goal for these interviews is determining the top risk factors in UAE's oil and gas construction projects that lead to the safety defects. The interviews expose several areas and risk factors that influence the implementation of safety engineering system. For example, lack of understanding and monitoring, poor communication, equipment integrity, workers skills etc. appears as a root causes for many safety challenges, disturbing the efficiency of the risk assessment. Most issues point to an absence of the integrated view mentioned in the literature review (and the main point of discussion in this research study). Both the interviews and the questionnaires help shape the framework elements that enhance the application and implementation of risk assessment. The essential concept of the framework is illustrated in Fig. 19 where three different examinations, technical, procedural, and behavioral should be conducted before reaching risk evaluation stage. The evaluation and the inputs of the framework will be based of the interviews and questionnaires outcomes in which the detailed mechanism of the framework function is explained in Chapter 6.

Chapter 6: Development of a new framework for enhanced risk assessment implementation

6.1. Framework concept inputs and mechanism

The aim of this study is to provide an integrated framework that can optimize the implementation of the safety engineering system through the usage of a risk assessment.

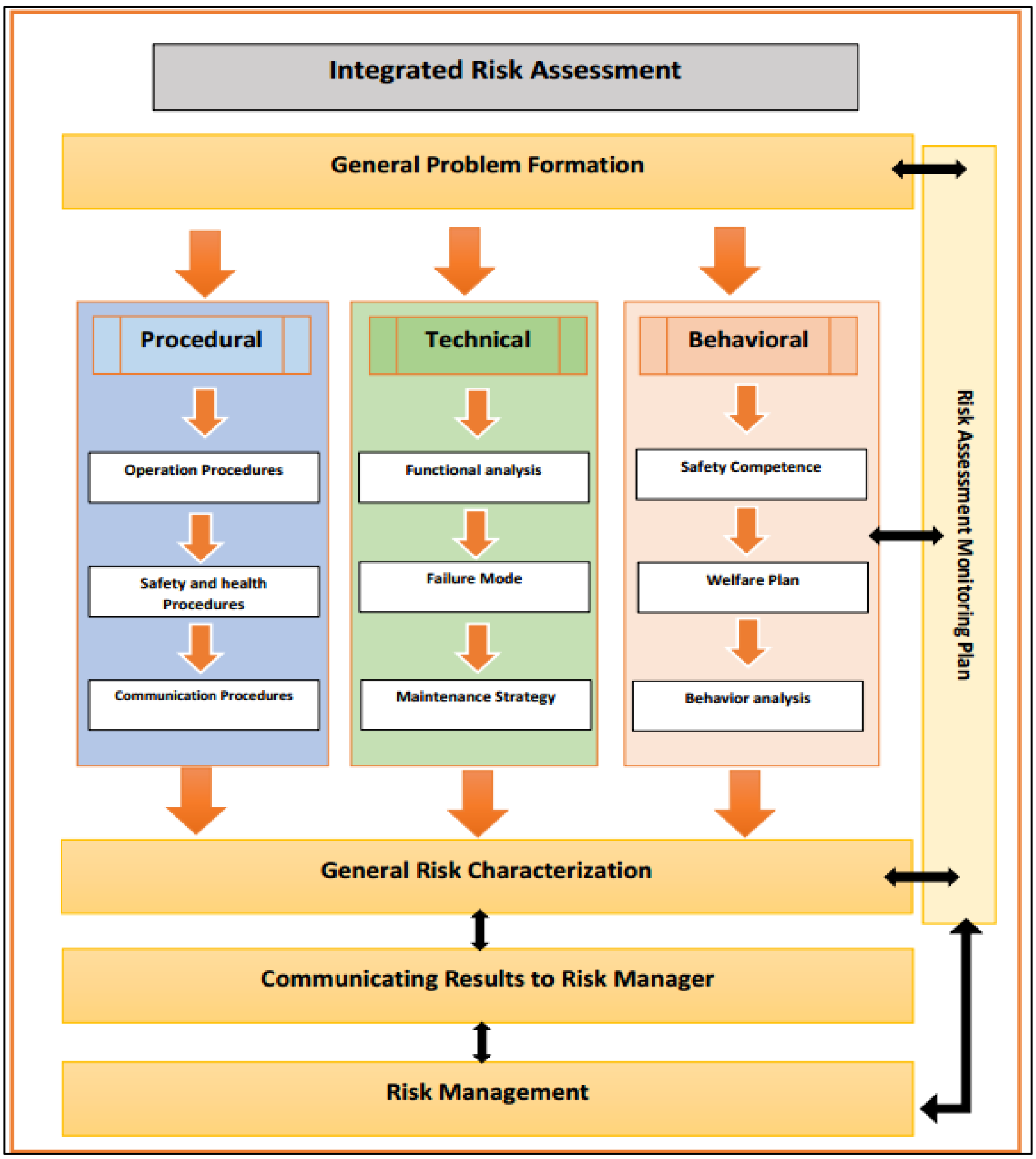


Figure 65: Integrated Risk assessment framework for oil and gas construction projects.

Both the questionnaire and the interviews exposed the presently weak areas in the risk assessment application thereby aiding the selection of the framework inputs in this research. As shown in the Fig. 65, there are three main sections employed as filters during the hazard identification stage in which each one of them has specific criteria. Such a focus will facilitate avoiding the kind generalizations practiced in most risk assessment sessions to cover all the possible scenarios that can occur with the existing hazards.

Each group has three standards that should clarify the identified hazard, its dimension and interaction mechanism with the wanted construction activity. Following this full examination, a regular risk assessment procedure is carried out where risk estimation and evaluation will be conducted in the General Risk Characterization stage. At the same time, risk monitoring will be involved in the all steps to facilitate a healthy communication between the parties, especially the management and end-users.

1. Procedural section

A. Operation procedures section

It is important to highlight the operational procedures that will be used in the construction task for all the employees who are participating in it. The first step is to indicate the manuals which the procedures are taken from them to help the job performers in identifying the main technical references. According to Hale and Borys (2013), providing these manuals during the risk assessment, entices a social motivation for the end-users to explore the procedural concepts and gain more technical information that can enhance their competence skills. Furthermore, having written procedures with manual reference offers a clear and precise summary for the execution of a complex construction task whilst also providing supervision for the workers on site (Embrey 1999; Skogdalen et al., 2001).

There are three main steps that should be followed, as shown in Fig. 66:

- Define the construction process based on activity analysis
- Develop and write the procedures
- Monitor the procedures enforcement

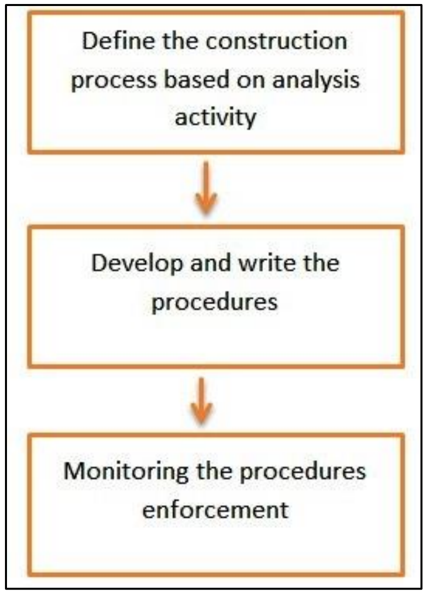


Figure 66: Operation procedures application steps.

For the first step, shown in Fig. 66, it is critical to define the entire process that should be followed in order to achieve the main goals of the construction activity, including steps, materials, time, and equipment. However, many scholars suggest reviewing the manuals to select the required process so as to enhance the construction target that may rely on the experience and the history of previous jobs for a similar activity. Often, it is required to change or modify the described process in the manuals due to the job nature difference from one location to another thereby necessitating the use of individual ability to learn. The modified process should be within the international standards acceptable range limit, without major violations to specifications that can lead to safety defects at the execution phase. Additionally, the process analysis needs to check the feasibility of applying the defined process with the available resources and start contacting the procurement department in case of shortages of materials.

Writing the procedures is the next step which should reflect the concept that was defined in the previous step and be suitable for the targeted job performers. To illustrate this, scholars like Antonsen et al., (2008), conducted an experiment to determine the gaps between the work as described in the procedures and the work that is actually performed in offshore site. They discovered that the best approach to deliver the message is through simplifying and clarifying the instructions to suit the end users' culture and education level. For example, the authors mentioned that the performance rate of the workers improved significantly on the site when they started discussing the procedures in their daily activities and safety meetings. Furthermore, the authors suggested that written procedures can help to extract suitable KPIs to monitor the safety culture at the workplace.

For the next step, monitoring the procedures contains two main process; evaluation and execution, in which these activities require a specific committee to continuously ensure the high level of performance and appropriate method of implementation. At the evaluation stage, it is suggested for safety engineers on site to conduct a weekly quiz for the workers to determine the quality and level of understanding. This will help to collect important information for the committee members and apply any necessary adjustment in the written procedures. However, for the execution stage, the committee members should monitor the compliance level of the employees through analyzing the safety performance and root causes of the accidents. Mapping the roots causes of the accidents with their procedural faults leads directly in improving the classification mechanism during risk assessment session.

B. Safety and health procedures

From the questionnaires and interviews, it was noticed that the three elements that requires improvement to enhance the safety and health procedures implementation are as shown in Fig. 67.

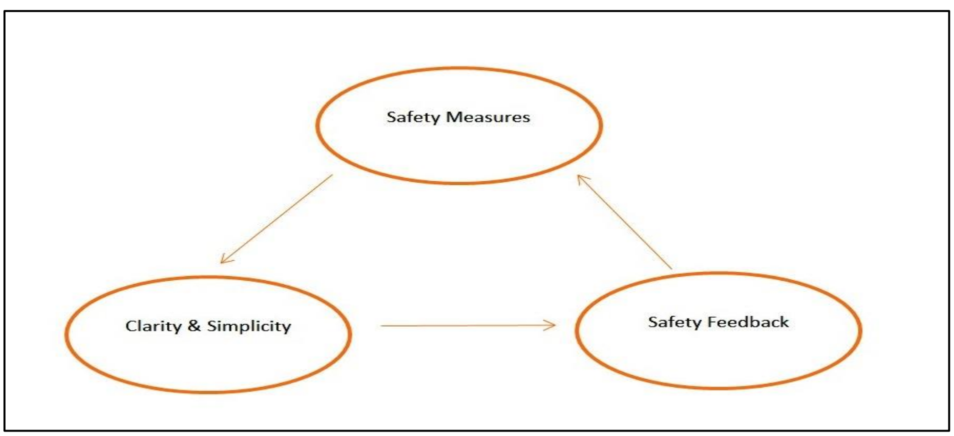


Figure 67: Safety and health procedures application steps.

Selecting safety measures from the HSE procedures is the key goal to provide the proactive and reactive measures against the different hazards for the required construction job. All the selected measures should be directly driven from the main organization manuals in a way that suits the surrounding environment. For example, man power size, the worker competence, and frequency and severity of hazards in which these factors should be examined for office and field employees who frequently engage with this selected activity.

Many of the HSE engineers capture the written procedures and embed them as safety measures in their integrity plan without any consideration for job performer academic background which may require more clarity and simplicity. To illustrate this, the safety and health procedures can be simplified by adding some drawing and figures that can be more understandable for labourers who have the language barrier issue. This can be displayed through separate posters that can be hanged on different spots of the construction location. Moreover, it is suggested for the safety engineers to explain these procedures by giving examples from pervious lesson learned which shows the importance of studying and analyzing the earlier incidents for the same wanted activity. However, one should always remember that the main goal of clarity and simplicity step is to enhance the compliance and not compromise or provide short cuts against safety performance. Having multiple and different contractors in the same site can be another challenge in this stage where each construction company have their own safety system. As such, it is extremely vital to explain and utilize the same safety measures for the all the workers whether they are form the client or contractor companies thereby helping the labourers to focus at one system to follow. Using checklist is another method that can provide clarity and simplicity concept in a suitable technique in the construction field. For instance, before conducting any construction activity, the end user should fill the safety measure checklist that illustrates the job procedures and then he/she submits it to the main supervisor.

Many scholars (Mikkelsen et al., 2004) define the safety feedback as the lost link that can ensure the workers' engagement with organization procedures. That is, the author mention that mangers deal with safety procedures as communication tool and this is a common mistake. They state that procedures are implementation guidelines that need to be communicated between the employees where feedback can play this role and this helps to apply continuous improvement goal in the future. This can be approached by forming a specific committee that its members are responsible to update and improve the safety procedures through the cycle steps as displayed in Fig. 67.

C. Communication procedures

The absence of oriented communication in many of the construction organizations is because they lack a clear communication procedure that involves all organization activities e.g. maintenance, materials supply, and construction. The usual practice, which is followed, explains and embeds communication briefly without mentioning the people and channels. For that, most of the risk assessment sheets do not provide any kind of communication information even for emergency cases. As such, this framework will enhance and fill the communication gaps that were shown in the questionnaires by providing a scheme that answers the three major questions; what, who, and how. The visibility of these three pillars of communication can eliminate the different barriers that may occur during exchanging information as shown in Fig. 68. This helps to ensure the success of communication in the entire construction project.

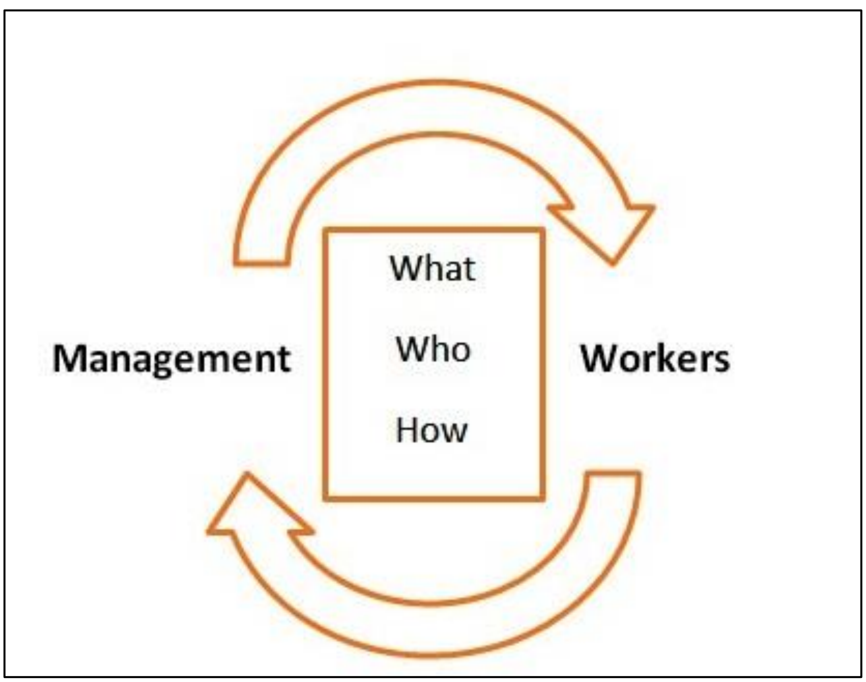


Figure 68: Communication Process.

- **Answering "the What"**

Knowing "the What", is the first and most critical element in the communication because it defines the targeted audiences and methodology that need to be followed. Following this, distributing the roles and responsibilities in communication will be visible during the risk assessment session. "the What" is frequently associated with the level of the risk that may occur at the construction sites, usually divided into three Tiers.

Tier 1, refers to the risk and hazards which can damage employees and assets in the surrounding area of the construction activities. When the risk extends to the safety buffer zones, Tier 2 classification and status should be declared in which management must intervene to mitigate the situation. Tier 3 is the riskiest state that can reach to the crisis and/or disaster level e.g. massive fire which requires the help of local authorities such as civil defense. The new initiative in this framework is that the hazards in "the What" are classified with their severity and communication level (Tier 1 to 3) to help to win time especially in the emergency cases.

- **Answering "the Who"**

All the staff, engineers or end-uesrs on the construction sites whether from the client or contractors companies should recognize who to communicate in regards to any safety matter. It is critical in this step to assign focal point on the site for safety communication purpose before starting any construction activity. However, as explained in "the What", if the risk escalates to Tier 2, the management should be directly contacted hence why an Incident Management Team (IMT) should be developed for every project. The IMT team will be instructed by the Incident Commander (IC) whose responsibilities are as follows:

- Committed support to the workers on the construction sites.
- Provide technical level support - manage the higher level impact of the emergency in the construction site.
- Deliver additional resources and equipment (logistics)

In the case of a Tier 3 situations, (IC) will be in charge of contacting the required local authority to attain the required support.

- **Answering "the How"**

There are various written and verbal methods of communication which can be utilized for the risk assessment purposes, but to ensure efficiency it should proceed from the management. For example, management leadership demonstrates total commitment to safety communications in order for the workers on the site, which in turn maintains the organization's credibility with staff and contractors. Pertaining to the written communication, Abduyyeh et al. (2006) believe that a technical safety handbook is one of the best approaches that management can apply to communicate with the workers on the site. The authors suggest that a suitable handbook should contain direct and simple graphs that clarify safety communication rules and regulations to employees. This will keep the workers abreast with the new legal and technical changes in terms of dealing with machineries, equipment and reporting incidents.

2. Technical section

A. Functional analysis

This framework presents integration between construction safety and systems engineering through functional analysis that explains the equipment parts and their utilities. This would help fill the gap in the questionnaire, especially in the machineries and equipment failures. There are several scholars who strongly believe that there is a lack of technical examination for the current automotive safety technology at the construction site (Saurin et al., 2008). This is due to the nature of the heavy equipment with their numerous parts which act as potential hazards for users and the surrounding environment.

As observed from the questionnaire, the workers lacking a higher education background are often unable to deal with construction equipment in a safe manner. Furthermore, the interviews explicit show that many of the construction organization do not have sufficient technical courses for their staff. For that, having functional analysis in the risk assessment will guarantee the awareness and control of work equipment to prevent any accident or injury. Furthermore, rapid advances in technology often make constant updating of their procedures difficult for organizations.

In this framework the functional analysis for the construction equipment will be divided into four main categories as shown in Fig. 69. These four aspects will enhance the proactive safety performance for the users.

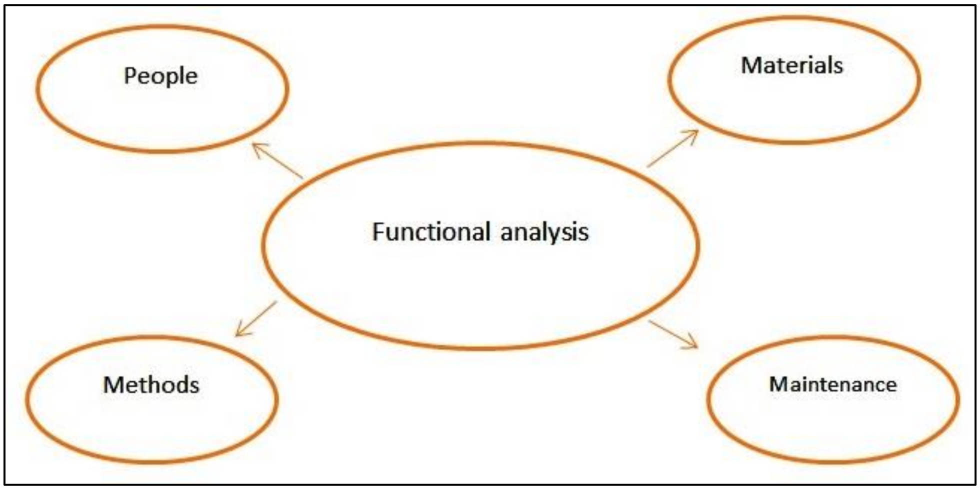


Figure 69: Functional analysis aspects.

- **Materials analysis**

In this step, the materials of the equipment are classified into chemical and physical characteristics, providing an integrated understanding regarding the equipment operation phase. As illustrated in the interview, the materials characteristics in the manufacturing and operation modes should be clarified and distinguished. This is similar to the idea of having Material Safety Data Sheet (MSDS) for the chemical used at the construction site. For example, many current pipelines used in the oil and gas industry are made from Fiber Reinforced Polymer materials (FRP) such as Carbon Fiber and Glass Fiber. There are several advantage of using these materials in pipeline construction due to the light weight and anti-corrosion features saving a lot of time and effort in the maintenance process. Unfortunately explosion impacts (a type of dynamic loading) are frequently present in the all streams in this industry thereby requiring impact/resistance structural materials. These materials have a very low resistance to the elevated temperature where their critical temperature is relevantly low comparing with other pipeline materials e.g. steel. For that, it is vital to deliver this kind of information in the risk assessment to let the engineers and planners put suitable prevention and mitigation plans for any emergency case.

The materials classification in this framework contains four categories; flammability, radioactivity, chemical and biological hazards. For the flammability, it is critical to assess the level and rate of ignition for the material because it helps to choose the right equipment for the wanted construction activity. For instance, the materials will be allocated as combustible and non-combustible resources through the labeling system helping the end-users to identify the suitable equipment for the assigned job. This can be very effective to prevent accidents especially for the hot jobs activities where many scholars refer to explosion issues in during these jobs e.g. welding (Chi et al., 2009).

There are several radioactive sources arising in the oil and gas construction sites, usually in the soil formation. Radon, for instance, is an active Naturally Occurring Radioactive Materials (NORM) that, even with small concentration, can have long term effects on human cells. Additionally, Radon is responsible for equipment radiation contamination at the site, a fact which most construction organizations are unaware of. Thus, heavy construction drilling equipment i.e. piling driving tools are usually exposed to such radiation contamination thereby necessitating regular checking using nuclear gauges. This would allow the maintenance department to have an inventory for the equipment with their radioactivity level as one feature of equipment suitability. Following this, the risk assessment process will be more efficient.

Verma et al., (2003) believes that the chemical and biological hazards in the construction equipment usually come from the raw materials and substance that are occupied or associated with them. For example, in the oil and gas construction sites, most of the cementing units that ares producing large amount of Particles Matters (PM 2.5 and PM 10) have serious effects on the respiratory system. Many construction companies only emphasis to wear the dust masks during the mixing stage and this is not enough to eliminate the PM hazards. There should be an exposure limit vale for worker daily usage. Furthermore for the chemical side, there are numerous of alkaline materials (e.g. adhesives) which has a caustic characteristic that can cause severe chemical burns to human skin in case of wearing the improper protection gloves. For that, it is very important in this framework to add occupational health aspect of construction equipment as part of jobsite protection.

- **Maintenance analysis**

Both of the interviews stress the fact that absence of effective maintenance towards the construction equipment is because of the lack of the communication between safety and maintenance departments. As a result, RAMS system was recommended to fill this gap in both of the interviews. In this framework the joint between safety and maintenance will be through defining the equipment life cycle in the risk assessment. For example, most of the oil and gas construction organizations use the color coding system which states the equipment condition for functioning at the site by labeling them with certain color (which refers to availability). Should the equipment not be safety approved, it will not be labeled by the agreed color. In such a case the equipment shall instead be sent to the maintenance department. However, Chavada et al. (2012) believe there are many gaps in this system hence requiring a complete approach to ensure the equipment's integrity is not compromised. After all, several equipment failures happen at the construction site due to the manipulation of the color coding by contractors due to the work load. This usually occurs when the client companies pressurize the contractors to raise their productivity rate.

To prevent any manipulation on the site, the equipment's maintainability should be defined in the risk assessment by the maintenance department. The documentation of the equipment preventative maintenance needs to be available during the risk assessment on the office and in the execution stage on the site. However, it will be difficult to mention all the equipment for each construction activity on the assessment sheet and therefore only main/critical equipment are involved. This maintenance strategy will help the senior management to monitor the equipment utilization and know which equipment are used more or less at the construction sites. Knowing these information can assist the management to have better equipment allocation plan saving time and reduce cost in the operation phase at the sites.

Moreover, safety engineers must ensure that all equipment have at least 90 to 100% of the repairs completed, since a high number of equipment failures take place due to inadequate repairs (Kittusamy et al., 2004). That is, many of the construction organizations try to save equipment maintenance period time by accepting repairs that are only 50 to 70% complete. In this framework, maintainability of the equipment involves complete repairs that assist both the safety and the maintenance teams to track equipment and their availability at the construction sites.

- **People analysis**

The people analysis mechanism here is more focused on the human factors contribution in the safety performance with technical equipment in the construction site. As an example, it was mentioned in both of the interviews; many labourers lack the required competence to deal with construction equipment that contains advanced technology. The relationship between changes in equipment technology and worker skills has been highlighted by many construction professionals. For instance, Goodrum and Gangwar (2003) consider the shortage of skilled workers to be one of the greatest challenges faced by the construction industry. Goodrum and Gangwar mention that the point of having technology in the construction equipment is to ease the physical work by shifting the energy from the labourers to the machines, but this can go wrong if there is a weak level of control. This stresses the importance of the training quality which is provided to workers by the construction organizations. According to Klein and Kleinman (2002), there is a major gap in the risk assessment towards examining the workers skills with the used technology at the construction sites. For example, the Klein and Kleinman suggest mentioning the names of the job performers for each construction activity during the risk assessment session because it aids in displaying the worker technical training background. Exposing the worker skills and the training they received will let the management observe the weaknesses in their employee’s skills, thereby highlighting the kind of courses would help in filling these gaps.

The error that most of the construction companies fall in is that if they employ expert workers with more than a decade experience on the sites, they do not feel obligated to enroll them in any training. This is unacceptable due to the continuous development in the construction equipment technology. For instance, there is a trend for lifting equipment to be more automated in order to reduce the human factors for any potential accidents which can be applied as new added features in the control panels in the cranes. Here, work experience will not be sufficient to reach the required competence to operate the mobile crane at the site. After all, many crane incidents arise due to a lack of the knowledge of the operator towards the advanced features and control panel configuration. As such, many professionals emphasize the auditing role of the training centers to ensure not only their quality but also that their course materials are updated with respect to the latest technology. By this, the certified labourers will have the advanced skills to effectively and efficiently operate the automated equipment and machineries at the construction site in a safe manner.

- **Method analysis**

The method analysis in this framework focuses mainly on the environment and condition of using the construction equipment. For example, according to Lingard et al., (2013) several moving objects accidents (e.g. excavator tracks) occur at the construction site due to poor visibility inside in the cabin. The authors believe the root causes for most of these accidents are related to the unsafe methods/conditions while using the equipment. This highlights the critical role of examining the method and environment of the job location aside from the technical features of the equipment prior to beginning an activity. As such, including method analysis in the risk assessment can expose the safety defects in the design phase where a good allocation between vital structural areas i.e. power lines and mechanical equipment, is required to avoid any potential accidents. Thus, it is necessary to involve the designers with safety and maintenance engineers together at the beginning of the risk assessment process to identify any design fault at the early stages and save design-change costs in the future.

Analyzing the interaction between equipment and external factors is another major step that should be conducted in the equipment method analysis. For instance, most of the electric construction equipment such as electric motors can functionally be damaged and become a serious hazard due to the heavy rain. Then, electric currents can be developed that can affect the workers at close proximity to the equipment. Furthermore, according to Janicak (2008), most of the electric equipment fatalities arise due to a lack of compatibility between the environment and control measures. For example, during high level humidity, construction workers conducting any electrical jobs should wear specific impact gloves which operate as an insulation layer against electrical currents. Furthermore, the author refers to a static electricity as a serious hidden hazard that frequently occur in the dry air in cold temperatures, with construction equipment acting as potential conductor for such electricity. To avoid this, grounding tools should be attached with the equipment and mobile machineries at the construction site to help dispel the electricity. As a result, this framework is designed to define the equipment and its suitable Personal Protective Equipment (PPE) with respect to the site condition during the risk assessment.

B. Failure modes

Lin D et al., (2001) believe that examining the functional analysis of the equipment is one of the vital approaches to prevent equipment failure on the workplace. However, the authors refer to the Murphy's Law concept i.e. anything that can go wrong, will go wrong, and for that control and mitigation plans should be involved in the risk assessment stge. In this framework a forward logic method will be used where all the possible failure modes scenarios are defined as shown in Fig. 70. Then, the processes after and before failure stage are evaluated to have complete and integrated view.

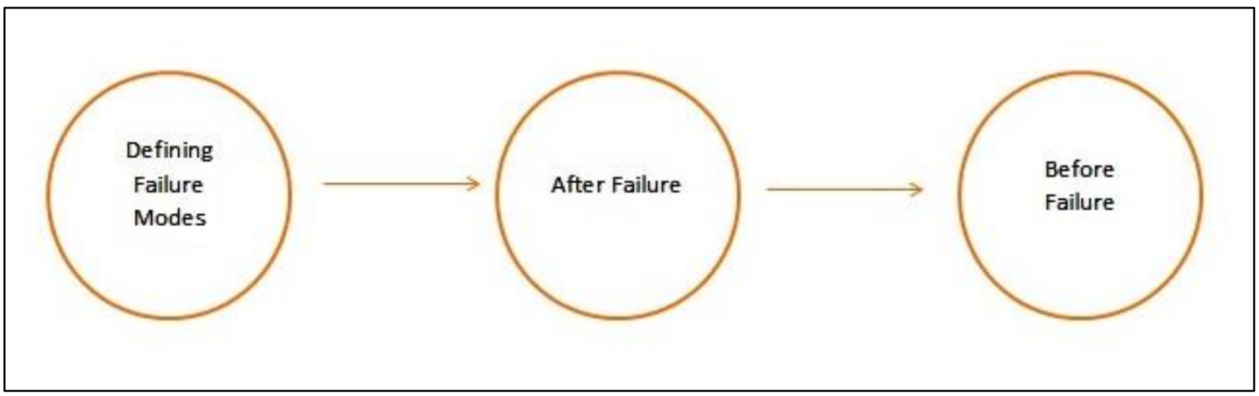


Figure 70: Failure modes analysis.

- **Defining Failure Modes**

As discussed in the literature review, knowing your hazards is the first step in eliminating it at the workplace and this is applicable also for failures modes. Construction sites in oil and gas industry witness frequent failure modes. However, it differs from one construction organization to another; depending on the construction activity provided e.g. exploration, extraction, refining, transporting, etc. For instance, in pipeline construction, pipeline rupture during installation is a common incident due to failure or improper usage of heavy excavation machineries. Here, the organization shall review these failures with emphasis on the immediate and root causes to provide solutions for the future projects. To illustrate this, the immediate causes for most of the pipeline rupture in the offshore site are related to the erosion, runoff and sedimentation where the root cause of all of them is mainly faulty laying and trenching.

These definitions of the causes will help shape the failure effects that may occur during the construction works, but it is far more practical for employees, especially end users, to apply monitoring practices. Monitoring the failure effects are divided into two main categories: people, and environment. Pinto et al., (2011), believe that supervision of these two factors is the last barrier layer in failure modes prevention. Applying this concept to the pipeline rupture, supervision practices to site environment can help the safety engineers to have more knowledge regarding the soil mechanics at the site. For example soil reinforcement can be applied in the offshore site as immediate action to strength the ground to have better resistance against runoff and sedimentation.

- **After Failure**

The "After Failure" section explicates the required emergency response that the crew at the site needs to follow to control and mitigate the situation before it escalates to the next level. The crew members at the site should have enough knowledge and training in communication as referred in the procedural section. However, a preliminary response plan has to be implemented until getting the full plan structure from emergency team in the head office. The main goal of this plan is to keep the work continuity with respect to the safety of the people and assets to reach to the business recovery phase. To reach to this stage as soon as possible, Lambrecht, and Lievens, (2008) suggest answering the following questions: what are the resources that are needed to be there in order to control failure impacts? What are the alternative plans available to precede the operation activities?

For instance, the authors mention the failure of diesel motors generation that are usually used in remote construction areas needs an immediate action from the workers on the site to mitigate it. This requires availability of resources of fire fighter team such as portable fire extinguisher, breathing apparatus, and fire-retardant coverall. Furthermore, after controlling the event, another motor generation will be required to continue the construction work on the site as business continuity plan. As a result, the authors refer to the necessity of mentioning the emergency resources and the way of utilizing them for each failure mode scenario in the risk assessment stage. As such, this framework focuses on the emergency recourse management and the importance of implementing them in the risk assessment.

- **Before Failure**

Detecting the failure mode is the chief goal of the failure mode analysis where forward logic is employed to analyse the technical system and improve the safety performance during design and construction stages. According to Liu et al., (2013), using this sequence of evaluation can aid the designers and safety engineers in understanding the dynamic between equipment/machinery and construction job. This integrated view helps identify all potential hazards that may lead to failure. As such, estimating the hazard and its severity and putting prevention safety barriers is the major key in this stage. That is to say, in the first stage (Defining the failure mode), it shapes the frequent failure modes and their immediate root causes.

In the "After Failure" phase, it shows how recourse management is needed to mitigate the risk. As a result of this exposure which demonstrate that explicit mitigation acts, putting prevention safety barriers will be more systematic with respect to the environment of the construction project. According to Guldenmund et al., (2006) that, failure of a single component in design stage can cause the failure for the whole system thus highlighting why identifying potential single-point failures is essential for determining problem. For example, cladding at the site can be divided to the following sub activities; installation, fabrication, reviewing the specification, and supervision/communication. The following single barriers can be added for each subsystem as shown in Table 5:

Table 5: Safety Component analysis.

Component	Hazards	Safety barrier
Installation	Lack of knowledge of the installers	Registered and Certified installers in the site
Fabrication	Lack of sealing and drainage	Pre erection safety check
Reviewing the specification	None compliance at the construction process to reduce cost	Continuous and effective supervision
Supervision/communication	Work load/ commercial pressure	Applying permit work system and motivation

Moreover, many designers prefer this way of analysis when it comes for materials selection to choose the right feature for suitable performance against the process construction and operation phases and factors that may lead to the failure mood.

C. Maintenance strategy

The questionnaires and interviews helped unveil all technical defects in the functional analysis and failure modes. Many construction professionals believe in the need of involving the maintenance strategy in the risk assessment of the project. For instance, Hung et al., (2009) believe that three maintenance strategies; predicative, prevention, and reactive should be applied for each construction.

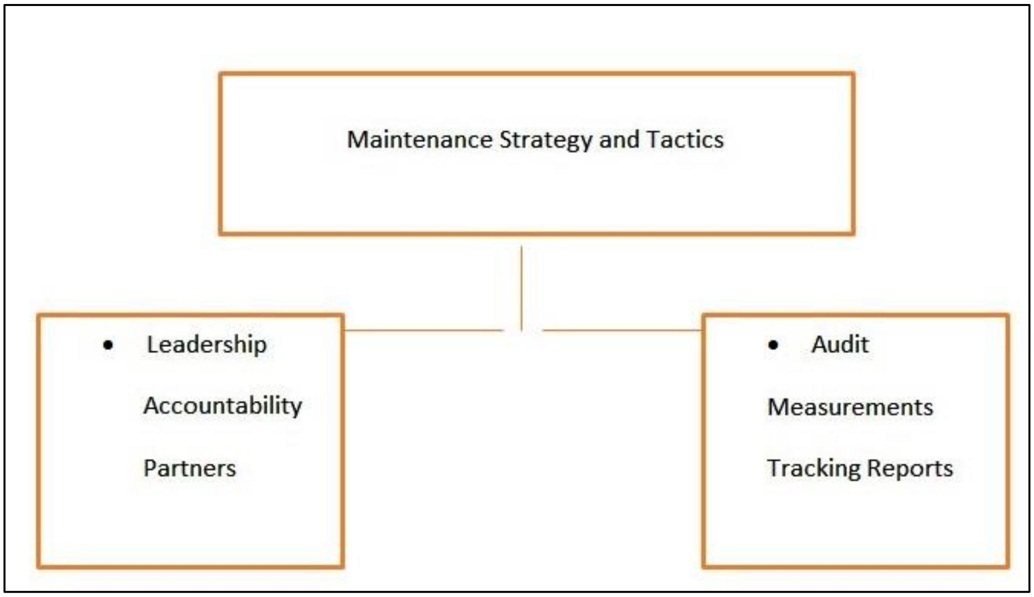


Figure 71: Maintenance Strategy and Tactics.

The authors describe how the current usage of these strategies in the organization requires a more specified focus. That is, traditional maintenance strategies may not achieve the production and safety goals because they are designed to preform before or after equipment breakdown. Such a superficial understanding of the role of maintenance strategy prompts management to make questionable decisions that translate into accidents at the construction site. As such, a new methodology will be introduced in this framework which involves border dimensions of the maintenance strategy, such as audit and leadership (Fig. 71).

- **Leadership and Audit**

According to the Sunindijo et al., (2007) leadership can serve as a vital contributor to performance indicator geared towards achieving a well-rounded implementation process at the construction site. This is particularly applicable to the maintenance phase where a variety of the organizations do not demonstrate enough visibility due to the fact that maintenance is not practiced in offices or the construction sites. Senior managers often display leadership with other senior employees in the office or when facing a large number of employees e.g. workers in the construction side. As result, a lack of implementation arises in the maintenance strategy activities.

Many scholars such as Skipper and Bell (2006) believe that leadership visibility is the solution which can fill such gaps. However, the authors indicate that the real challenge in maintenances strategy leadership is finding a managing strategy where important competency elements are being monitored, such as accountability. The relationship between leadership and accountability depend on one another where the absence of one affects the other. For example, most risk assessment sheets of the maintenance activities only refer to the senior maintenance engineers and technicians. This practice is usually defined as non-accountability job assignment that leads to non-commitment attitudes amongst the employees. This, if left unchecked, can further escalate into a behavior barrier against the planned strategy. To enforce the leadership accountability in the maintenance strategy, the following actions are advised for the top management in the organization.

Firstly, assuring senior management level support and involvement in the maintenance training program. This promotes accountability of the management in developing the employee skills in areas other than production. Additionally, management participation in the near misses and incident investigations reflects the management commitment in fostering a culture geared towards implementing the desired organization strategy.

On the other hand, Tang et al., (2009) illustrates that the goal of a construction partnership, from safety perspective, is to share risks and gain a better emergency response. However, the authors state that the lack of private-public partnership in construction projects disrupts the flexibility of the maintenance strategy. According to the authors there are three straight benefits from having external maintenance partnership: involving the external parties in implementing the organization strategy, reducing direct maintenance services cost of the organization, and providing a faster response in case of failures at the site.

Jones et al., (2006), shed light on how failure in implementing the maintenance strategy is the main cause of extra costs in the construction project. For example, the authors suggest that safety and health management system audits should include compliance towards the maintenance strategy. Moreover, the authors suggest involving external maintenance partnership in these audits during various project phases.

In this framework, the main point of examination in the auditing process is the maintenance measurements that describe the organization performance towards the maintenance strategies. The benefits of auditing these indicators, as Kumar et al., (2013) elaborate, is that they help determine maintenance strategies such as condition based maintenance, reliability of the equipment and maintenance productivity. The authors emphasize the importance of examining the role of Maintenance Performance Measurement (MPM) as a qualitative and quantitative approach that can measure complex functions such as maintenance activities. The audit mechanism focuses on two key aspects to assess the maintenance system: effort and result indicators of MPM. These indicators provide a balance perspective for the senior management. For example, effective indicators display whether the construction job is completed, has led to the expected output indicators, and ensured that the desired quality of output has been achieved.

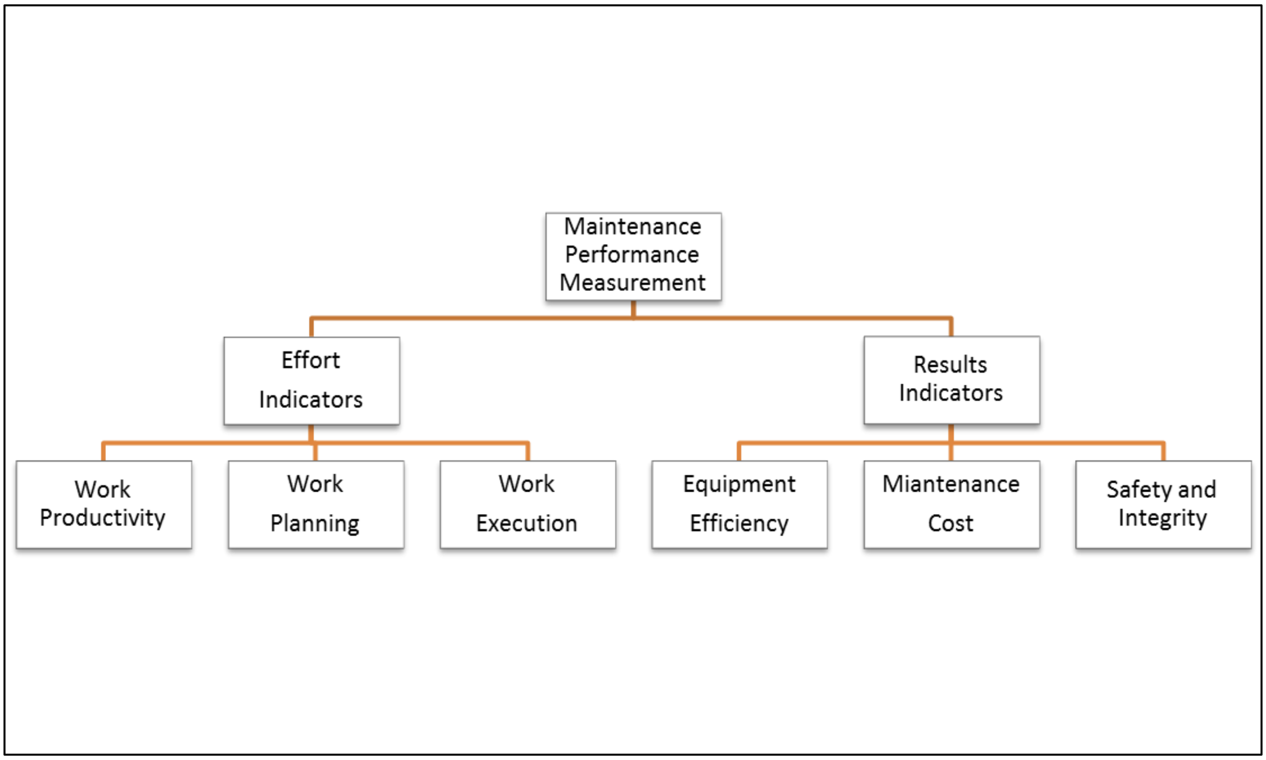


Figure 72: Maintenance performance indicators.

Tracking reports can be utilized to measure the effectiveness of these indicators via auditing and continuous monitoring is also required. The main purpose of the tracking reports is to provide real-time information of the maintenance status at the construction site. Combining auditing and tracking reports provides senior management an opportunity to evaluate the implementation process of the maintenance strategy and an efficiency indicator in reflecting the safety performance.

Furthermore, tracking reports help the organization reduce maintenance cost by providing an inventory that illustrates all the information of resources as project data. Therefore, in future projects, this data will display a better link between the maintenance s, materials, equipment, and machineries so as to attain an integrated reporting system and lower the chance of any redundancy in the project.

3. Behavioral section

According to Garrett and Teizer (2009) that the difference between human factors and behavioral analysis in construction safety depends mainly on the worker beliefs. Garrett and Teizer illustrate that human factors are more associated with factors affecting the individual performance e.g. training and equipment usage. In on other hand, behavioral section strives to examine all the attributes that influence the worker beliefs which can be developed into attitude and then to constant behavior. Both interviewees as well as most of questionnaire respondents echo each other in asserting that behavioral safety is the most important prevention barrier at a construction site. However, most safety professionals settle on the challenges that associate with the implementation process. These challenges can contribute due internal or external reasons as the questionnaire and interviews display. For example, from the questionnaire, the external factors that affect the behavioral safety performance for the employees can be classified into three categories: employee capacity, organization, and work environment. According to Clark (2013), all these factors are related to each other and to have an efficient BBS program at the workplace, it is vital to implement an approach that continues to link these areas together. This explains the three themes, i.e. safety competence, welfare plan, and behavior analysis, in this research framework which imitates the responders and interviewees opinion about the current status of the behavioral safety performance. Understanding the interactions mechanism between these three points is a key challenge that top management should address in order to foster a healthy safety culture at their sites. Fig. 73 clarifies the main stream of the interactions between these behavioral safety aspects where the ultimate goal is to promote a healthy safety culture at the workplace.

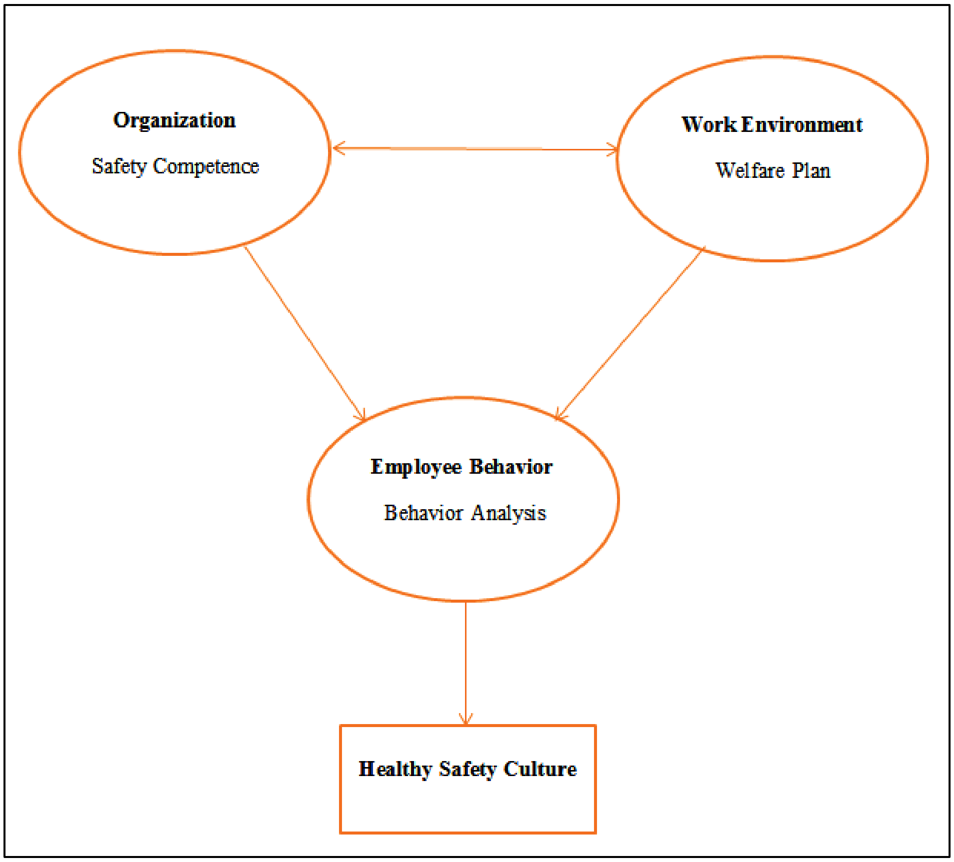


Figure 73: Behavioral safety elements interaction.

A. Organization factor

Organization factors play a critical role in the Applied Behavioral Analysis (ABA), comprising of significant features such as supervision, leadership and etc. However, scholars such Zohar and Luria (2004) believe that behavioral organization factors have a direct effect upon worker competence. For example, as the second interviewee mentioned, most oil and gas organizations provide only the basic safety courses for their staff, usually at the beginning of their tenure. Evaluating the training matrix of the employee, especially for the workers at the site, is extremely important to determine the level of their safety competence and how it could improve in the future. Due to the complexity of the oil and gas industry, most workers complain about other organization factors that may affect their safety competence as the questionnaire display in this study. For instance, work load, poor visibility of managements, and blaming culture can disturb the worker safety competence even if he/she has received adequate technical training course.

As a result, senior management should deliver healthy organization factors that motivate end-users to augment their safety competence through initiatives such as safety bonus and supervision care. Langford and Sawacha (2000) suggest several practices for the organization to enforce safety attitude at the workplace. For instance, having joint safety training between safety supervisors and workers at the site strengthens the safety culture in the long-run. Additionally, the authors believe that organizations should establish a clear policy illustrating how any worker has the right to refuse a task that he/she has not been trained in. The commitment of the organization towards these healthy practices will build a perspective that the company cares about the workers' personal safety and is more willing to cooperate.

B. Work Environment factor

Construction workers need acceptable rest, washing facilities and food. To ensure the behavioral safety of the worker, the welfare plan should reach beyond these basic requirements. According to Harris and McCaffer (2013), welfare is one of the most serious hidden work-environment behavioral factors that cause vulnerability in the workers' technical skills. For example, several health and physical issues often appear due to a poor welfare plan for workers at the site.

The questionnaires and the interviews point to more examples regarding the negative outcomes of organization compromising on the welfare plans. When welfare services quality declines at the site, the end-users lose the incentive to be creative and give innovative feedbacks to improve the safety system implementation. This framework highlights that an ineffective utilization of working environment factors has an equal effect on the managerial and field activities. This should encourage the organization to gain a wider perspective about the impact of an informed welfare plan that establishes a safety culture in their current and future projects.

Emerging welfare plan in the risk assessment as essential element within all other technical ones, increase the chance to have more suitable work environment factors for the labors at the site. That is, analyzing technical activities highlights the kind of services the employee needs to safely perform the required job. For instance, most pipeline construction projects require ablebodied laborers who are able to perform the different activities, such as bending and lifting. Here, risk assessment will help the top management and project supervisor select younger labors for these activities and assign older ones for other jobs at the site. Moreover, involving a welfare plan in the risk assessment provides the asset engineers with a better idea in the layout of welfare facilities that need to be installed, such as heating facilities during cold weather.

Wong et al., (2007), support the importance of having integrated welfare plan that runs parallel to the technical work at the construction site. However, the authors encourage most industrial organization to conduct a separate risk assessment after the welfare resources installation to avoid any incident that may occur during the operation phase. For example, several incidents occurred in the construction projects due to incorrect storing of cylinders in non-ventilated places outside the workers' accommodation.

C. Employee Behavior

Mohamed (2002) supports the concept of how employee behavior is highly related with other behavioral external factors in which shape it as the last barrier of behavior safety. As such, the organization should avoid focusing solely upon analyzing the worker safety behavior without considering the organization and work environment factors. To attain a meaningful evaluation of the worker, indicators from both management commitment and work environment ought to be monitored in a continuous manner. Selecting the indicators is the key obstacle that an organization needs to cross in order to ensure they have fair monitoring system.

Management commitment is a vital indicator of the organization behavioral safety since it can exceed beyond establishing policy and procedures. For example, management commitment is the essential element of creating a supervisory and supportive environment at the construction site. When an end-user feels that his/her management prioritizes his or her personal safety over productivity, the communication transparency will increase in the organization. At this point, tracking the behavioral analysis of the employee in the daily activities will be easier. That is, the more emphases from senior staff, the more oriented supervision toward worker behavioral safety is applied as result of management activities e.g. manager's visits to site, managers-workers and open discussion.

Nahrgang et al., (2011) encourage worker involvement as one of the main behavioral indicators in the behavioral analysis system. Management should be more willing to provide active and passive control to end-users. For example, workers can participate and contribute in decision making of safety policy and procedures. As such, more individuals will gain appreciation for the safety behavioral and its importance, eventually shaping a healthy safety culture at the construction site.

Understanding and applying these new indicators will help the organization utilize an update in the industry. For instance, as was explored during the questionnaire and interviews, organizations use a performance mentality to analyze the worker behavior at the site. Such a mentality is propagated by the idea that unsafe behavior is fundamentally linked to workplace accidents records and scenarios. As such, accident data is considered the key indicator for judgment.

This framework analyzes the effort put forth by management as part of employee behavior. The reason behind this focus is that employee behavior influences the technical skills of the workers. That is, most behavioral safety incidents at the construction site come from experienced workers who required revived several trainings by their management. However, concurrently, management often fails to stress the role of behavioral safety at the workplace. To attain a safety culture at the workplace, an integrated examination of the employee behavior should be conducted. This will aid safety engineers understand the root causes of unsafe practices, instead of focusing only on the act-doer and the required disciplinary actions.

6.2. Validation of the Framework

A. Quantitative approach

As can be seen in Fig. 65, there are three key areas that need to be covered to gain an integrated understanding of the potential hazards in a construction project. After selecting the indicators, Total Positive Outcome Indicator (TPOI), will be employed to know the efficiency of these indicators to reflect the safety implementation and its effects on the performance. TPOI method concept has been mentioned briefly in a several occasions from construction professionals (Wallbaum et al., 2012) that it relies on the positive leading indicators. In this framework, the proposed TPOI is further integrated by taking into account employee efforts, management commitment, and the organizational structures in place to promote a safe workplace.

- **Indicators and research objectives**

The objectives of this study are examining the current safety challenges that affect the implementation process in the oil and gas construction projects. The chosen indictors should reflect the gaps explicated in framework, questionnaire and interviews, as shown in Table 6. For the procedural indicator, auditing and follow-up check is the main indictor to evaluate the compliance level of construction execution, with respect to organization safety procedures.

Table 6: Performance Indictors of safety implementation compliance.

Indicator	Area	Objective	Measure	Example
Audit and follow-up checks	Procedural	Compliance towards procedural requirements	• Number of audits and follow-up checks	• 8 hours for each audit and follow up
Equipment verification	Technical	Avoiding the equipment failure in the site	• Number of Equipment verification	• 4 hours for each equipment verification
Maintenance assessment	Technical	Fill the gap between the safety and maintenance departments	• Number of equipment that have full completing repair	• 72 hours for each full completing repair
Welfare examination	Behavioral	Providing comfortable level of welfare services for the workers	• Number of Welfare examination • Number of training provided to the end-users	• 8 hours of the welfare examination • 7 hours for each day of training for each worker

The proposed framework, in the procedural section, provides conceptual steps that involve all major areas such as communication, technical, and safety performances. As such, a number of specific and dedicated audits and follow-up checks will be utilized as performance indictor of management commitment. These procedural audits, occurring once in each quarter, ought to cover all faults highlighted in the procedural section. For the follow-up checkup, it has to ensure that all the procedural audit findings are fulfilled and there is an action plan that explains the methodology employed to achieve it. By applying this procedural performance indicator, the optimization of sustained safety regulations can be monitored and tracked.

Equipment and their failure modes were the most technical highlights referred in the framework. These two areas serve as the objective of study i.e. exposing the technical safety challenges at the construction site. As a result, equipment verification is a vital technical indicator since it aids both the safety engineers in the field and top management in guaranteeing equipment integrity. Additionally, using equipment verification as an indicator aids the technical managers to continuously observe the machineries performance and optimize the operation goals with respect to safety measures. Furthermore, maintenance assessment will be employed as the second technical indictor in this framework. Maintenance assessment enables industrial professionals to achieve one of the objectives of this research in filling the communication gap between the maintenance and operation departments. For example, the assessment process involves reviewing the maintenance records status and availability of the equipment parts before operating them at the construction site.

Moving to the behavioral indicators, the framework illuminates the critical influences that become the root causes of low behavioral safety performance by the end-users. Here, low qualities of welfare, such as poor housing, greatly affect workers' technical safety. For instance, as shown in Fig. 73, employee behavior can be directly influenced by organizational and environmental features. As such, the selected performance indicators must reflect these influences.

The first indicator is welfare examination that determines how satisfied workers are with the facilities provided by their organizations. This examination should focus on the physical and mental aspects. Accelerated production rate and reduced cost are the immediate causes of a compromised welfare quality. According to Hoonakker et al., (2005), these safety initiatives appear when the emphasis shifts towards a well-rounded safety culture at the workplace. However, the authors stress how the organizations must ensure their end-users' technical capability to sustain healthy behavioral safety. This can be achieved by measuring the planned training hours against the actual training hours delivered to the workers.

- **Applying the performance indicators in the construction projects**

The first construction project is for National Oil and Gas Construction Company, considered one of the most active construction contractors in the onshore concession. The construction project period is estimated for two years (2016-2018). The main goal is providing pipeline network to transport hydrocarbon from several well heads to the refinery in the operation plant. In this section, a benchmarking exercise between TPOI and TRI will be conducted to show if the indicators can provide an integrated risk assessment to optimize the safety performance. For example, all the man-hours of the four indictors are calculated in term of TPOI from Q1 to the Q4, represented by the green line in Fig. 74. According to Siu et al., (2004), most organizations conduct numerous safety meetings and reviews at the beginning of the project. Later on, however, the effort towards safety declines because the focus shifts to all the operation challenges at the construction site. This is obvious in Fig. 74 where the TPOI man-hours declines dramatically form 68,000 hr in Q1 to 34,000 hr in Q4. This reveals the compromise and non-commitment of the senior management towards the initial HSE project plan. As such, this finding accurately reflects the implementation problem this research attempts to explore.

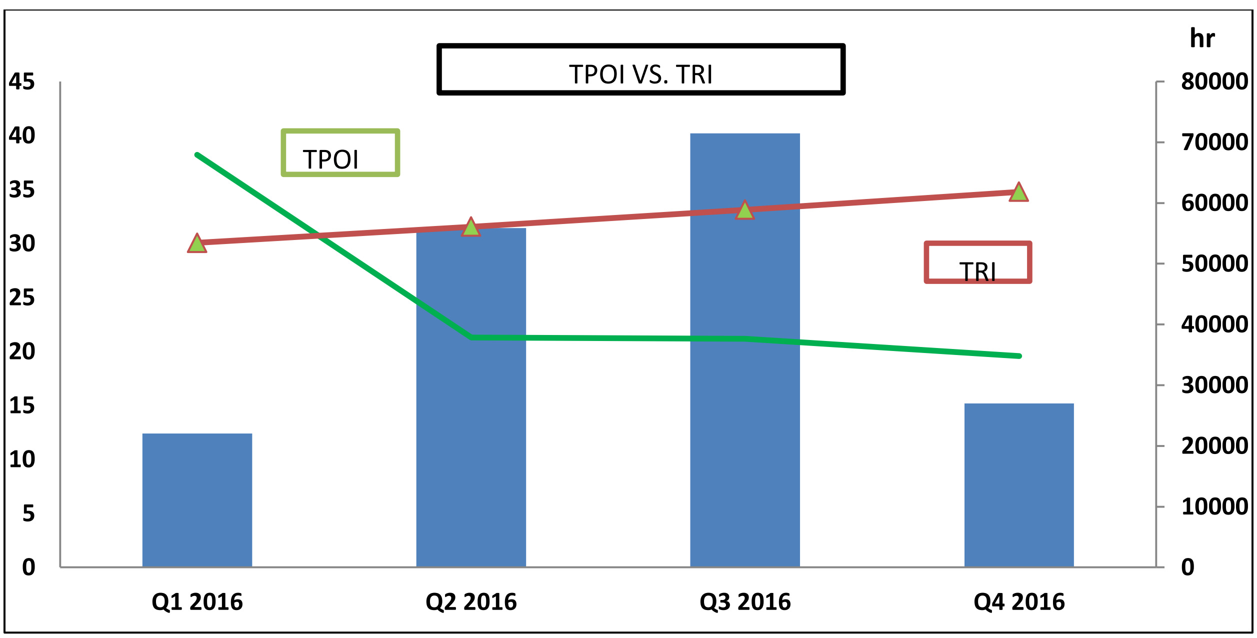


Figure 74: TPOI VS. TRI for pipelines construction project.

Furthermore, the columns in Fig. 74, represent the actual man-hours spent at the construction site. When compared with the TPOI line, an inverse relationship can be highlighted.

For instance, in Q2 and Q3, when the project reaches execution stage, the physical work at the site increases to achieve the production targets. As a result, management tend to emphasize in the operation aims and get relaxed with safety measures as shown in the intensely decline of the TPOI in Q2 and Q3. As such, it is expected that, the total number of the incidents increase as TRI graph displays in which the lowest numbers occur in Q1 and highest in Q4. The behavior of TRI in Fig. 74, reinforces the research's claim that root causes of incidents manifest when the top management compromise on the safety plan implementation. As such, when the man-hours spent on TPOI decrease, more incidents are expected to be occurred at the construction site. As such, management in the organizations should utilize performance indicators and TPOI as alert method for inadequate safety performance lest a real accident occur.

The second construction project is for CONMIX Company that provides cementing services for several hydrocarbon structures in the UAE, both at the onshore and offshore construction sites. The project is examined through the performance indicators similar to the pipeline construction project, but here the statistics are presented in monthly basis due to the smaller size of the project. The goal of this project is to provide ready columns in 10 months' period to an offshore rig in Das Island, as shown in Fig. 75.

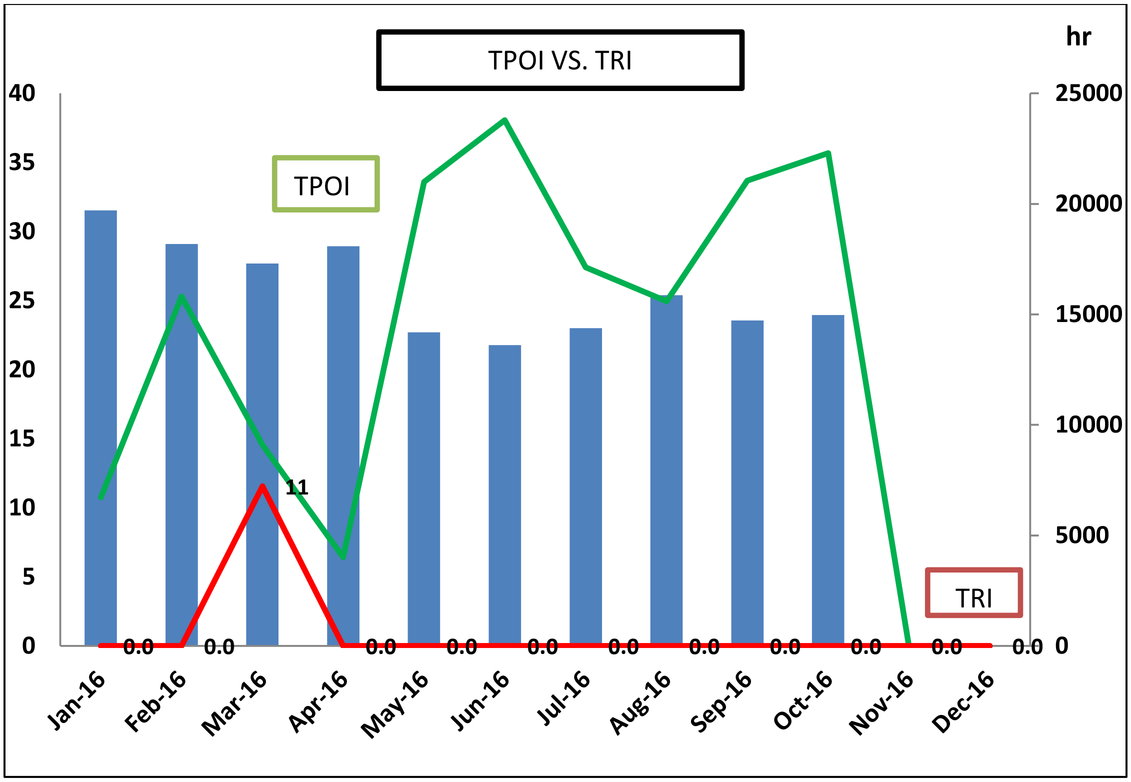


Figure 75: TPOI VS. TRI for offshore concrete structures.

The workers are exposed to variety of hazards at the workplace. They are especially vulnerable during mixing the concrete, pouring the concrete mix and opening concrete forms. As evidenced by Fig. 75, the company spent high rate of man-hours in several areas of safety system as TPOI pattern displays. Most organizations tend to do so in the beginning of the project. However, between February and April, TPOI plummets, simulating the company negligence toward implementing the safety plan. As such, accidents start occurring in the second week of February and reach a maximum with 11 TRI in the beginning of March. An increase in the number of TRI due to the decline of TPOI was observed in both projects, as shown in Fig. 74 and Fig. 75. However, the response of the CONMIX managers was to regain their high safety performance and spend more man-hours in implementing safety system than at the site. From April to June, there was a significant improvement in the TPOI pattern that reflects the management effort on improving the safety applications, technical, procedural, behavioral. It reaches its maximum rate in the middle of June with 23,000 man-hours, without recording any incident at the construction site.

According to Zou et al., (2007), organizations achieve maturity level when dealing with risks, if they start changing and updating their tradition practices in both operation and safety perspectives. This mentality shift can be dedicated in this project in Fig. 75 when a slight drop of TPOI occurred between June and August. Here, the company did not count on the zero-excellent record of TRI, and bonus back to recover the high rate of TPOI. The explanation behind that is that, the CONMIX Company experienced how relying in incident records lead the management to get eased and relaxed with other vital indictors as what occurred between February and April. As such, the TPOI rate increases again and reach to 21,000 man-hours in October as shown in Fig. 75.

In the both construction projects, the performance indicators (represented via a TPOI pattern) show how most organizations have a good implementation at the starting stage of the project. With time though, a negligence and carelessness attitude develops that reduces the rate of TPOI and increases TRI.

From analyzing both Fig. 74 and Fig. 75, it is evident that every time there is a decline in the leading indicators, an accident will take place in the field. For example, in both projects, the number of TRI appears immediately once TPOI pattern has declined past a certain point. As a result, TPOI has the potential to be utilized as a performance indicator and an alert to the management before accident occurrence. Additionally, as shown in Table 6, TPOI reflects an integrated approach towards optimizing the safety system implementation. This will aid management in identifying not only the root cause but also areas that require improvement in the risk assessment (Fig. 65).

B. Qualitative approach

This study provides a new conceptual framework of how the risk assessment can be utilized to optimize safety implementation at a construction site. This framework simulates the need for more integrated method, as the literature review explicates, to fill the current safety gaps in the hydrocarbon projects. Furthermore, the structure of the framework is derived from the questionnaire respondents' and interviewees' analysis.

Although this framework has been examined by several industrial professionals, there is a necessity to evaluate the framework from an academic and industrial perspective. For example, Wimbush and Watson (2000), use a qualitative approach in their study which delivers a framework that optimizes the quality of health at the workplace and public areas. According to the authors, using qualitative approach granted them a wider scope when predicating future challenges upon the proposed framework. Industrial experts often find themselves focusing on current obstacles without considering the resilience of the framework against dynamic factor e.g. adoption and change management. As such, this method allows safety professionals to gauge the long-term suitability of a proposed framework.

In this study, the first interviewee serves as key evaluator for the framework. Before starting, the evaluation process should be categorized to avoid an imbalanced examination. For example, the following categories are used in different stages of the evaluation: feasibility, performance and measurements of the framework. According to Kahan (2008), these categories can provide an integrated understanding for the framework mechanism for current and future challenges. The author believes that sustaining the high functionality of the framework is the key target that the evaluator must determine during his/her examination process.

- **The First Evaluation**

The evaluator has a strong background in construction safety. He has been involved in several projects as safety advisor and consultant in hydrocarbon projects. Additionally, he frequently publishes papers on the role of safety and risk factors during construction activities. Before starting the evaluation process, the framework had been explained and reviewed with the evaluator to provide a comprehensive view. The evaluator agrees how hazards and risks are highly associated with the hydrocarbon construction projects due to the nature of the work. He believes in the need of continual improvement in implementing safety in the construction field. According to him, safety systems in the oil and gas industry suffer from accidents due to the lack of implementation where professionals keep trying to fill this gap through different approaches. Utilizing risk assessment as a proactive approach can strengthen the system implementation if executed strategically. The evaluator simulates risk assessment as the safety eye in the project that needs to be placed on the right spot to detect all the possible hazards. This justifies why many scholars indicate the need of having an integrated method to cover all safety challenges that affect the implementation process. The evaluator elaborates that this framework presents the possibility of using risk assessment as an integrated method to solve the implementation safety defects in the construction field.

- **The Feasibility of the Framework**

According to the evaluator, that the proposed Framework in Fig.65 has a new concept which includes technical, procedural and behavioral aspects. However, the examination should examine the practicability of applying this framework within the project plan during execution. The evaluator believes that the technical structure is oriented more towards the equipment safety. Additionally, merging elements such as function analysis and failure modes helps involve maintenance and reliability perspectives in the risk assessment process. The evaluator believes that a common mistake most organization make is not involving all the resources integrated with the usage of the equipment. For example, integrity of the equipment itself cannot prevent accidents since other factors contribute in the process e.g. people and methodologies. Therefore, the evaluator supports using the function analysis method to cover all hazards from various factors. However, to have an accurate application of function analysis, a reliability engineer should be involved in the designing and execution stages. According to the evaluator, this would allow the Framework to be more efficient in all subsequent steps. As Fig. 70 illustrates, the evaluator suggests that the mode of failure requires a forward logic understanding that employees with a reliability background are more familiar with. Concurrently, collaboration with safety engineers is vital to select the best emergency response in case of equipment failure in the construction field.

As such, the evaluator stresses employing safety and reliability engineers in all technical elements in this framework. This would result in the implementation of a visible strategy to improve the safety in the technical aspect. However, the evaluator believes that having a separate maintenance strategy (as suggested by the framework) could be a challenging initiative. This is because most organizations are used to a general strategy for all the projects and shy away from time-consuming initiatives. According to the evaluator, this can be eliminated gradually after employees in office and field grow more familiar with it. For example, Fig. 71 suggests that maintenance tracking reports of equipment should be delivered on a frequent basis during the operation phase of the project. Such an activity is rare in the hydrocarbon construction industry, thus requiring time and effort before it can be practiced effectively.

For the procedural section in the framework, the evaluator advises that the feasibility of the elements is simple, but it requires accurate work to reach to the planned targets. For instance, the evaluator explains that Fig. 66 and Fig. 77 illustrate in a clear approach the mechanism in how to extract operational and safety procedures that suits the project resources and environment. Despite that, the evaluator suspects in the quality of the extracted procedures if the employee in charge is not competent enough in the both of technical and safety aspects. Therefore, the operation and safety procedures should be written simultaneously for the wanted construction activity to have a comprehensive view for different employees. Generally, the evaluator finds the idea of having a specific technical, safety and communication procedures is a unique one and has several benefits for the main organization procedures. This should be observed through applying continuous update from the lessons learned in the construction field. In this point, the evaluator suggests increasing the feasibility of the procedural section in the framework to conduct benchmarking exercise with local and international construction safety agencies. The evaluator justifies this remark that focusing only lesson learned to improve procedures is a narrow perspective in technical and safety perspective. Yet, this is not applicable for the communication procedures as the evaluator highlights. For instance, organizations have their own communication chart and methodology that suits the nature of work at the site benchmarking exercise will not add a lot of vales to the communication procedures. Apart of that, the evaluator supports the idea in Fig. 68 in which it clears the main three aspects of communication, what, who and how, for all employees in the office and construction site. However, the evaluator believes this mechanism can be modified in a way to be more feasible by adding communication officers as a medium between workers and management.

For the behavioral section, the evaluator states that the safety behavior concept is the major gap most organizations fail to apply in their safety system. According to him this framework is oriented more towards the behavioral safety of the end-users. Though a vital part of safety implementation, this alone is not enough since poor behavioral safety starts from the management level. For example, Fig. 73 demonstrates how the interaction mechanism between the employee and various behavioral factors. Yet, this should be narrowed and classified into three levels: managerial, supervisorial, and laborer. This can be more visible and feasible if the figure could illustrate how the lack of safety behavior in management has a direct effect upon the end-users' performance. As a result, the evaluator suggests adding a general behavioral analysis.

The evaluator justifies this suggestion by pointing out how, in his experience; the root cause of unsafe behavior for the workers is poor safety behavior of management.

The evaluator believes that human factors are more related to the non-technical skills such as leadership, communication and stress management. Thus, this section of the framework should involve such soft skills. The evaluator supports his view by citing several studies that have been conducted by behavioral safety professionals, for e.g. Dainty et al., 2005, Smith et al., 2002, and Gilley et al., 2009.

- **Monitoring Plan for the Framework**

As the evaluator stated, that the proposed Framework in Fig. 65 is more conceptual where it may cause some complications for construction organizations during the implementation process. For that, an implementation plan is developed that contains practical guidelines that can ease the execution process for the industrial sectors. As it was illustrated by the evaluator, that there should be a defined role for each job category in the organization with a visible and clear job description. In other words, the construction organizations tend to agree in the highlighted elements in the Framework, but still they need the answer of the following question, how we can do it? This can be answered through having monitoring plan of the Framework which was not clear in Fig. 65.

As shown in Fig. 76, that monitoring plan involves all the gardens of the employees in the organization in two main phases. The design and operation phases include variety of communication dimensions that aid each employee in office or site to implement the integrated risk assessment progressively. For example, as the evaluator mentions, the management should have a clear description of the potential project with visible goal in which each employee including worker has enough knowledge in his/her role.

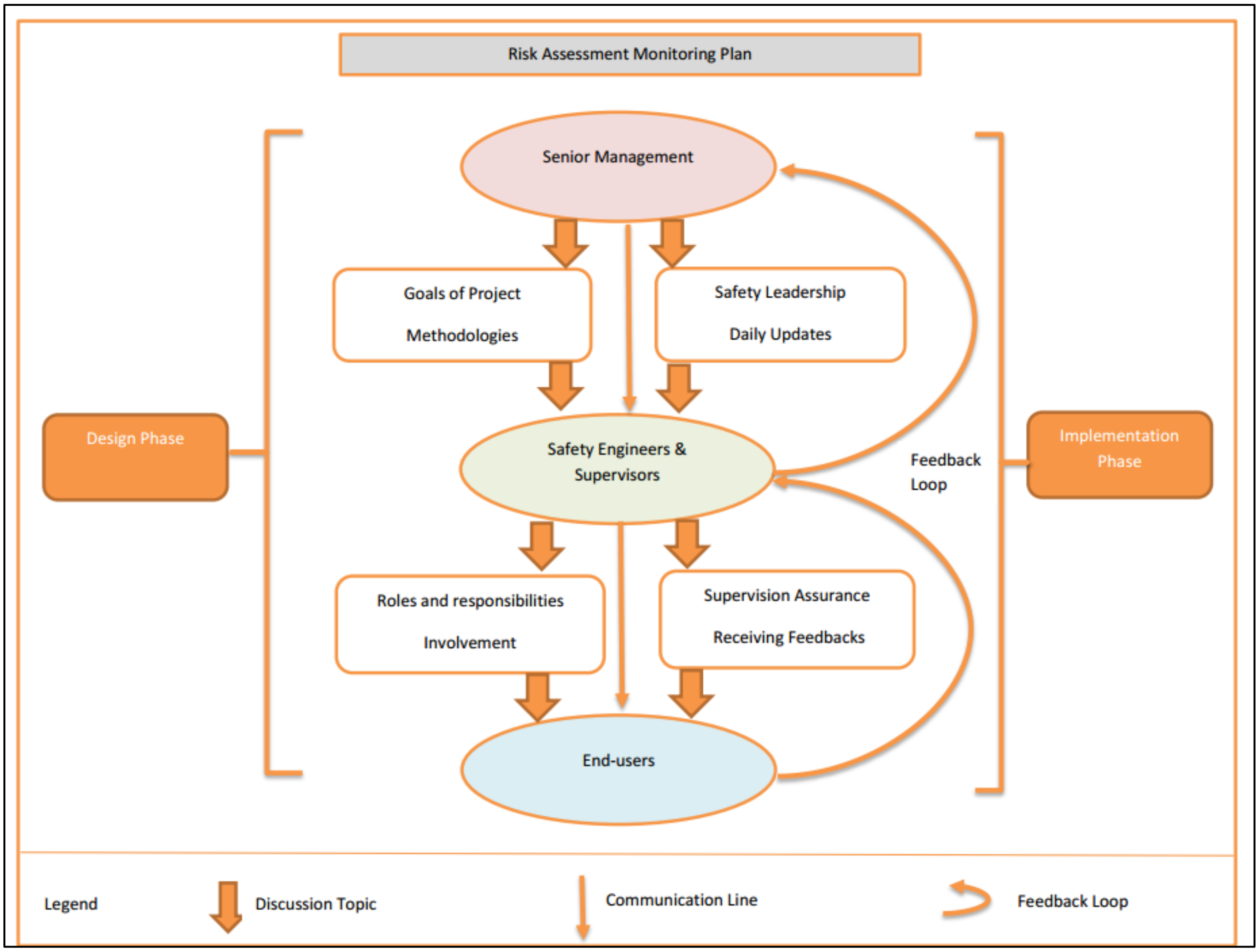


Figure 76: Monitoring plan of the Framework.

However, the details of the project goals should be delivered with respect to the employee role and responsibilities to preserve an adequate level of understanding without any complexity. For example, Cheung et al., (2011) mention that many of the construction companies share their project aim and objectives with all their employees without simplifying these information for the end-users. For instance, the involvement of the workers in the design stage is a very vital, but it ought to be applied in suitable way. As consequence, safety engineers and supervisors will play a key role in the simplification process to raise the level of the awareness of the organizational culture between the workers. In addition, the senior management needs to agree on the technical methodologies which should be used during the execution phase that encloses equipment and machineries. For more illustration, both of the interviews and evaluation stages display a major safety challenges in the equipment that are used during the construction activities. As result of that, defining the approaches that are going to be utilized in the project, aids safety engineers and supervisors to narrow the potential hazards in the site and become more focused on preventing or mitigating them.

Furthermore, this mechanism can be enforced through having explicit roles and responsibilities especially for the end-users. The importance of this step is that it prepares the labors to determine their work scope and safety instructions which give them the right to reject any risky job activity. In this point, as the evaluator stresses, during the risk assessment, when the role and responsibility are defined with considering the safety perspective, it displays the message of delivering the job in a safe manner. As result of that, the job performer will not compromise the safety value over production rate even if he/she is facing high work load. After that, as shown in Fig.76, the involvement is going to be more sufficient in the design stage because each employee can contribute with a better level of knowledge. For example, when the worker participates in the pipeline laying process, the worker can propose a more realistic suggestion due to his expediency with construction site environment. Due to that, all the pervious elements; roles and responsibilities, project goals and methodologies could be updated and enhanced before moving to the operation phase.

Moving to the operation phase, to enhance the monitoring of the Framework in Fig. 65, practical steps are advised to be followed that can go parallel with various applications of the integrated risk assessment. For example, senior management should demonstrate efficiency to their leadership in order to support the new approach of applying risk assessment during the entire implementation process. This action provides a vital support for the Framework especially in the behavioral section. Ofori, and Toor (2012) believe, that the implementation of technical elements in the safety systems relies mainly on non-critical activities such as management leadership. For ease of understanding, the authors give example in the end-users behavioral in the construction site and how it is highly associated with management visibility. As the Framework explicates, elements such as welfare of the employee when it gets direct supports form management, it displays the care of organization on the workers comfort. This eventually motivates labors to work in a safe manner in the site. However, safety leadership can be distracted if there is a poor communication in the process. For illustration, the communication procedural section in Fig.65 focuses in answering the main three questions: what, who and how. Yet, as the evaluator highlights there is a need to conduct a frequent meeting between the management and supervisors in the site to check on the risk assessment implementation. For example, in the oil and gas construction projects, it is a usual practice to that project engineer to submit a daily report about the operation status to the management. To simulate this, as shown in Fig. 76, that daily updates between safety engineers and management aids the organization to be informed on the safety condition and how it could be improved. According to Kine et al., (2010) in their paper that verbal communication can play a critical role on improving safety in construction. This can be approached either by using official channels i.e. reports or unofficial approaches such as virtual meeting.

The next important task that the both of the safety engineers and supervisor need to deliver is effective supervision on the workers in the site. As it was illustrated in this research, inadequate supervision is one of the direct causes for the safety incident in the construction field. As it was mentioned in the second interview, most of the construction organizations utilize the role of supervisor in the technical aspects which gives negligence attitude to occur against other safety features. For that, as shown in Fig. 76, supervision assurance element aims to have more integrated safety role for the supervisor e.g. procedural and behavioral characteristics. This mechanism widens the role of supervisor in a way that he/she should be aware of all aspects of the needed supervision activities in the construction site.

Yet, there is another vital contribution to ensure the integrity of the monitoring of the Framework. Workers feedbacks are extremely significant to determine how the Framework is exposing the workplace hazards and how they could be mitigated. Therefore, listening and transferring their feedbacks about Framework gives the chance to the management to apply some changes in the implementation mechanism. For example, as the questionnaire displays that most of the workers are not satisfied with the welfare services that their construction organization provide which eventually reflects in their safety performance. As consequence, both of the safety engineer and supervisor need to allocate a specific time to pay attention towards workers opinion and suggestions to the application of the integrated risk assessment. Therefore, the Framework in Fig.65 will be combined with Fig.76 to strengthen the risk monitoring element as shown in Fig.77.

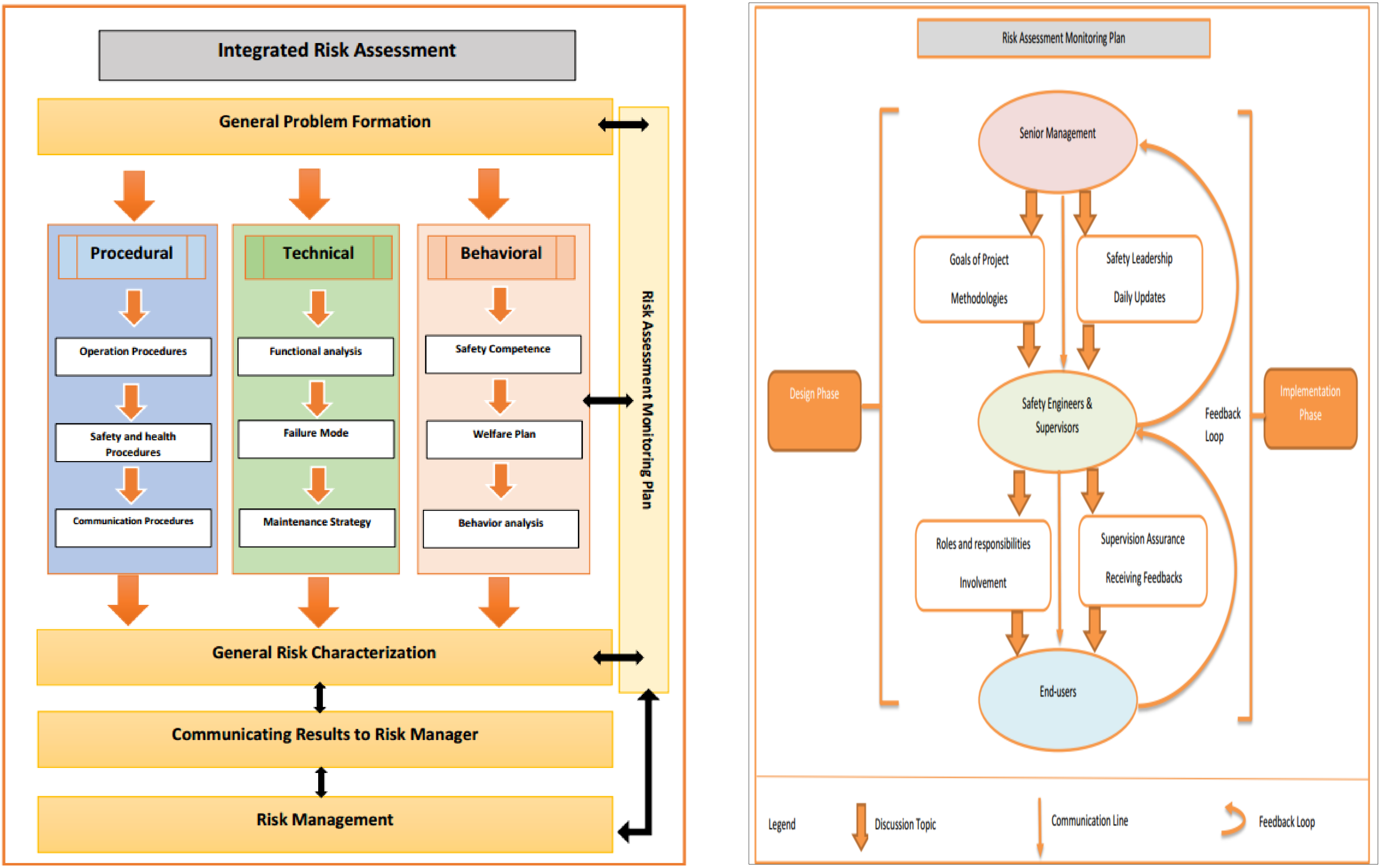


Figure 77: Modified Integrated Risk Assessment Framework.

- **The Second Evaluation**

The first evaluator highlighted two critical aspects of the first proposed framework in Fig. 65; the adaptability of the framework and the monitoring plan. For further explanation, the first evaluator stresses on the role of change plan management in enhancing the efficiency of the framework implementation. Hence, this plan aids each category in the organization with necessary steps to adapt the changes in the risk assessment changes. Moreover, as Fig. 77 displays that risk assessment cannot be fully integrated if there is no visible communication. A clear communication should involve the entire organization employees from the management to the workers level.

Although Fig.77 explicates a modified version of the integrated risk assessment by the first evaluator, there is a need for another validation especially from the operation and workers perspective. The second interviewee was selected as the second evaluator since he has a solid background in the construction operation. As in the second interview, employees with construction field experience can spot hazards that are hidden to managers in the organization. For that, the modified framework in Fig. 77 was presented to the second evaluator to know how it can optimize the implementation process of the safety system in oil and gas construction projects.

Starting from the procedural section, the evaluator supports the concept of involving the workers in the procedures whether the technical or the safety one. According to the evaluator that having workers representative i.e. supervisor on reviewing the required procedures can add several benefits. For example, the supervisor will know all the safety references that he should go back to in case of any technical/safety emergency. In addition, this involvement of the supervisor helps him to deliver the required message to the workers in simplified approach. Moreover, the evaluator emphasizes on the role of the communication procedures in which it provides visible channels for the workers if they have any inquiry. This should go alongside with a clear role and responsibilities as the risk monitoring plan suggests.

In the technical aspect, the evaluator believes that all the integrity and safety aspects of the equipment should be checked before the worker perform the required job in the site. For that, the evaluator stresses in the necessity of collaboration between the safety and maintenance departments as the framework displays. For example, technical examination such as function analysis and failure modes should supply the elementary technical safety judgment skill to the supervisor. The evaluator elaborates that these basic technical skills would be enough to implement the supervision assurance as the risk monitoring plan shows. In addition, from the end user point view, having maintenance strategy will ensure that all workers should receive the prerequisite training in case of using new technologies. This practice has several safety benefits especially for the experienced workers who are used to work with certain technical equipment for long period. In the end of the technical section, it is critical for the safety engineer to report the equipment performance on daily basis for maintenance department and senior management. The active communication provides the maintenance engineers and managers to take proactive actions in the event of risky and non-safety performance of the equipment in the site.

Thirdly, the evaluator states that the framework in Fig. 77 contributes in an efficient approach to preserve the safety behavioral of the workers in the construction site. For instance, the evaluator highlights how vital elements such as worker welfare impact the safety performance and the importance to link it with risk assessment. According to him, many of incidents in the site are associated with poor welfare services and they contribute as root causes. Unfortunately, most of the construction organizations do not follow this logic in which it results in compromising welfare aspect for operation purposes. Moreover, the evaluator says that having open channels in in the risk monitoring plan between workers and supervisors, gives the chance to address all the welfare defects that face the workers. As consequence, the senior management should be able to detect any gaps or decline in the provided welfare services to fix and enhance them. Moving to the safety competence, the evaluator supporters the concept of Fig. 73, that safety competence it is not only an individual attribute, but it interacts with other influences. Due to that, construction organization should widen their view to include other factors apart from technical training only. For example, assigning the appropriate work load for each worker that suits his/her technical skills and physical features. However, the evaluator said even with having all the required measures, the safety leadership by management is a key to attain the safety behavior of the workers. This safety leadership ought to be more than site visit as the risk monitoring plan illustrates, in which it should be visible on a daily basis. Then, more accurate behavioral analyses could be applied.

The evaluator trusts in the concept and mechanism of the framework in Fig.77 in raising the safety awareness and providing better protection for workers in the site. The comprehensive interpretation of this risk assessment framework offers a good opportunity to the worker to be involved with different aspects of the projects e.g. technical or procedural. According to the evaluator, this involvement has another dimension than enhancing the safety performance in the site. For instance, effective involvement substitutes the gap of general knowledge that most of the workers suffer due to the limited education that they had. With time, the raise of the knowledge between the end users will reflect positively in many attributes in terms of improving the quality of work of the construction organization. The evaluator concludes that this framework can be updated and modified after implementing it for a sufficient time without compromising its core concept which is the integrated viewed.

Chapter 7: Conclusion, Recommendations, limitations and further research possibilities

7.1. Conclusion

This study strives to optimize the safety performance at construction projects in the oil and gas fields through implementation of risk assessment. As can be gleaned from the literature review, many scholars elucidate their struggles with current applications of risk assessment and the needs for an integrated approach. The aim of this research is to involve all vital and contributable areas that can cause an accident as immediate or root source. Technical, procedural, and behavioral aspects were investigated with respect to the external and internal attributes that play a critical role in the oil and gas industry. Pervious risk assessment frameworks could not provide an integrated perspective to identify the full scope of the hazards at the construction site. To have an integrated view for better safety implementation, an integrated examination should be conducted. To determine the possible threats at the site, all the employees in the organization have been questioned through a survey that was distributed as a part of the field work in this research.

Exposing the current gaps in the organizations' safety engineering system was a vital step towards detecting the key elements that had to be strengthened in order to enhance the implementation process. There were unexpected points raised by both management and end-users, providing a glimpse at the various barriers towards the implementation plan. For instance, both management and end-users indicate some gaps in the technical skills, either due to the lack of training or communication between departments. Furthermore, this stage of the research explicates the difference mindset between management and end-users in how the safety and operation procedures should be utilized. A major challenge arose in the behavioral aspect especially from the management side. For example, most managers who participated in the questionnaire, lacked vision when it came to how welfare is associated with workers' behavioral safety at the site.

These primary assessments need more investigation so as to construct coherent framework that can optimize the safety performance. As consequence, both interviews and benchmarking practice were conducted to help this research perceive the hidden attributes behind these unhealthy acts.

The same methodology was followed in the subsequent stage of the research where two main interviews involved a senior manager and a supervisor to discuss the early outcomes of the questionnaire. These interviews helped to understand the internal and external influences that create unhealthy attitudes between managers, engineers, and workers. For example, most equipment failures occurred at the construction site due to poor communication between safety and reliability engineers in the field. Yet, it could be related to a procedural defect e.g. failure in updating the operation procedures with respect used technologies at the site. This highlights how having multiple viewpoints can affect the implementation process in several ways either by management or end-users. As such, in the both interviews, the importance of involving employees was highly stressed.

The field work questionnaire, benchmarking, and interviews in this research allowed spotting vital elements, as illustrated in the Framework at Fig.65. The Framework provides conceptual strategies that deliberate both academics and industrial concerns. For instance, in Fig. 69, functional analysis methodology was suggested to be not used in the equipment itself only, but with all the influences that interacts with it as well. This approach of usage of functional analysis shields the scholar's suggestions in the necessity of utilizing functional analysis with risk assessment. Concurrently, construction professionals indicate the importance of involving other factors such as people and materials as part of equipment integrity. Furthermore, the Framework introduces new features of behavioral safety during the risk assessment, ensuring the behavioral communication between management and workers. Sub elements, which involve behavioral analysis, open the permanent channels for both managers and workers. As the two interviews emphasized, when the behavioral analysis is applied, the management awareness and responsiveness towards their workers' essentials is augmented. This, in turn, improves welfare made available to the workers. As shown in the Framework, these comprehensive features of the element and sub-elements gives this Framework the strength in implementation of the safety engineering system.

Since construction is a very practical field, especially in critical industry such as oil and gas, there is a need to examine how this Framework will be adopted and applied with the current situations. The evaluators expounded that the impact of the Framework is different from one employee to another depending on his/her role in the organization. For example, the evaluator claimed that the organization should prepare a plan that involves all employee categories: senior staff, Middle management, and workers. According to the evaluators, this provides each category to implement the Framework process in the rate and methodology that suits its function at the site. Additionally, the evaluators highly recommended continuous response to the workers' feedbacks which improves the framework and its implementation. Moreover, to optimize the safety performance, the evaluator suggested several healthy practices which must be applied along with the Framework. For example, since equipment failures are very common at the construction site, having reliability engineer at the site can play a major factor to eliminate these unwanted events.

7.2. Recommendations

This study examines the safety performance and implementation at the construction oil and gas rigs. The reviewers of this research emphasize the new integrated approach that contains vital attributes to optimize the safety system execution. As was shown in this study, safety engineering is a very dynamic field that requires a consecutive improvement. For example, according to Green (2011), in his book Making Sense of Construction Improvement, the safety presence in construction should be updated frequently with respect to other influences, such as technology and shortage of resources. Green elaborates that stagnated; obsolete systems in construction pertaining to safety engineering systems will act as implementation barriers.

In effect, this study presents the following recommendations that can provide the chance for other researchers and professionals to utilize the conceptual product this framework displays in altered approaches and purposes.

- **Creating numerical model that reflects the risk assessment performance as of safety implementation**

Having numerical model has many research potentials where it can aid the organizations to develop software to measure the safety implementation in the operation phase.

- **Studying in depth the role of human factor in affecting critical technical elements**

As shown in this study, there was a large gap in applying and monitoring the behavioral safety performance by management. This study exposes vital contributed element i.e. welfare, that can dramatically influence the workers' safety output. As result, a detailed study is highly recommended to determine how human factors affect the safety implementation and management role in oil and gas industry.

- **Providing other proactive KPIs for construction safety**

This research presents a new concept of measuring the safety performance in the construction sites. For instance, this study focuses on the amount of energy management expends towards safety engineering system, including meeting, training hours and etc. As such, for construction safety improvement, other proactive KPIs could be examined to gauge their impact on the safety performance e.g. quality control, supply chain management, and Life cycle costing.

- **The adaptability of framework**

Generally, the evaluators agree with the feasibility of the proposed framework, proposing some modifications that have been illustrated above. However, it is critical to examine all categories pertaining to how the framework will be adopted by the organization, i.e. senior management, engineers/supervisors, and end-users. As such, it is important to discuss the adoption strategy in three different layers and what obstacles may arise against the implementation mechanism of the framework.

A. Senior Management

The key challenge for adopting any new framework lies in how the organization manages the change. Supporting this view, many scholars such as Rozenfeld et al., (2010) identify management implementation as the crucial factor that influences the successful adoption of a new framework. For instance, according to the authors, there are several proposed frameworks that succeeded in some construction firms and failed in other. Construction firms should always implement any new changes gradually. The fault occurs when the organization wants to fill their safety gap instantly which results in poor implementation.

As a result, besides applying management of change towards the proposed framework, risk management audit should be conducted frequently e.g. quarterly basis. Utilizing risk assessment framework will differ from one Construction Company to another, depending on internal factors such as organization capital and man power. Management must examine how these factors interact (via audits, for e.g.) with new risk assessment techniques to gain a better management of change strategy. According to Spira and Page (2003), such findings may assist senior management in determining the level of efficiency of risk assessment as well as purveying a realistic evaluation of the new adopted mechanism.

In the end of this section, the resistance from the mangers is a common obstacle during any initiative that may affect the production rate. This is mainly due to a lack of understanding. However, management of change and risk management audits can gradually assist senior staff to adopt the framework. This facilitates updating any internal or external factor that may affect the implementation mechanism. As consequence of that, all direct report employees under senior management can effectively transfer the framework concept to the end-users.

B. Engineers and Supervisors

The role of mid-career employees in adoption of new framework is essential due to the complexity of oil and gas construction projects. There are two main challenges for engineers and supervisors. First, they should participate with senior management during designing the implementation mechanism of the framework elements. Toole (2005) explores how increasing engineers' role in the design stage can provide extra safety opportunities and barriers. Many of the organizations rely totally on management to execute the implementation. However, Toole indicates that construction safety is a very dynamic field which requires a continuous exposure and reflection from the site to gain a realistic image of the laborers and work environment. This point of view echoes the idea of involving engineers and supervisors with managements in the early stage of the implementation plan.

Transparency when overlooking the workers' feedback and progress with the new Framework is the second task for engineers and supervisors. In the first stage, understanding the management view is the key challenge. There is, however, an additional step that is required. For example, both engineers and supervisors should have the necessary communication skills to explain the proposed framework to the end-users. According to many construction professionals (Knight and Graydon, 2007; Sageev and Romanowski, 2001; Williams, 2006) there are several obstacles which usually engineers face during communicating with the end-users at the site. That is, things that could be common knowledge for the engineers may be foreign concepts for the end-users e.g. wearing PPE at all times at the site even if there is no operation. Additionally, complex technical need to be delivered to the workers in a sample manner. Due to that, using simple language with abundant visuals, e.g. graphs and charts is required to reach to the end-users.

In the end of this section, it is critical to emphasize in the role of engineers and supervisors in reflecting the workers' adoption of the new Framework. This involves both the physical performance and individual behavioral performance of the worker at the site. The organizations often content with only the management understanding the new initiative. This narrow perspective can be replaced if both engineers and supervisors transfer workers' implementation to the management on a frequent basis. The key benefit of this practice is that the senior management will receive live feedback from the construction site. This results in providing the senior management a window to adapt to any elements of the implementation plan as required.

C. End-users

This study points to the workers' safety behavioral performance as the main indicator of success of the proposed framework. As illustrated earlier, monitoring and providing any resources for end-users is the responsibility of senior and mid-level employees. These external and internal factors play a critical role in the approach of how workers adopt the proposed framework. According to Manley (2008), a direct safety communication encourages the end-users to show more initiative pertaining to the implementation progress, especially in their core tasks. For example, the end-user should be able to ask for safety explanation at any time, either officially (e.g. PTW) or unofficially, before conducting the construction activity. Furthermore, workers have the right to request technical training in case of using new technologies in the field.

The more the worker is visibly active with the safety challenges that he/she faces at the site, the more engaged the senior management will be. The evaluator explains that, rather than fostering a blame culture at the site, the visibility of both management and workers can shape a healthy coaching culture at the site. That is, when a worker reports a safety obstacle, the safety engineers save a lot of time during the investigation to determine the root cause. Once the management eliminates the blaming, the visibility of the end-users' increases. The evaluator believes eventually this practice improves the implementation process of the new framework.

Finally, as part of the vitality of the end-user feed backs and visibility, this research stresses the importance of the Framework's welfare section. This is a new concept related to the risk assessment in construction with workers' welfare, boasting several advantages in adopting the framework. For example, when workers express their satisfaction with the welfare facilities, this provides an indication of their capability to learn and implement the Framework procedures. To maintain this healthy culture, it is important to encourage the end-users to be involved as key participants in the welfare section during risk assessment and report any defect that could occur in the construction operation. As a result, the senior management in the organization will emphasize the workers' welfare as a factor in which it can enhance safety and production rate simultaneously.

7.3. Limitations of the study

This study provides a new perspective towards optimizing the implementation of safety engineering system. Academics, scholars, and construction professionals suggest using an integrated mechanism to enhance the safety implementation at the site. The essential mechanism was delivered in this research by providing an integrated Framework as shown in Fig.65, which illustrates how to fill current safety implementation gaps. However, as with any research, there were constraints affecting research methodology.

According to Atieno (2009), time constraint is a very common factor that influences the selection of a suitable approach to achieve his/her research objectives. For example, in this study, the majority of the construction rigs examined were onshore rigs, since over 90% of UAE oil and gas construction are located there (ADCO, 2012). Despite the similarity of the construction procedures between onshore and offshore sites, a focus study in the offshore may expose specific safety threats. That is, there are different external factors such as see water level, harsh weather and water salinity that impact the equipment and structure of the offshore rig. As such, utilization of the risk assessment should take into account these attributes, their impact on the organization communication and end-users' behavioral performance.

Furthermore, several interviews have been conducted during the questionnaire phase, where two of them were represented as key interviews. Since construction is a very complex field that has variety of views point, it would have been more comprehensive to have extra key interviews. The two key interviews represent the main perspectives (Senior Management and End-users). However, to determine all immediate and root causes of the lack of safety implementation, additional input is required on each perspective. For instance, construction managers in the same organization have different technical backgrounds e.g. installation, maintenance, etc. Such diverse experiences may potentially expose a more detailed sub-element in this framework.

There is also a lack of previous risk evaluation studies that cover the safety performance implementation in the construction phase of oil and gas industry. As such, to get the fundamental information about the current gaps, a questionnaire with statistical analysis was the suitable approach. In case of availability of earlier studies that provide critical analysis or numerical models, this would help the research to cover this topic from a different perspective. As a result, under the 95% confidence internal for a population of about 4000 employees and a margin of error of about 5%, a representative sample size was chosen. The sample size could be stretched if there is more flexibility with research timeline. Apart of the constraints that are explained above, the validity of the research undertaken and its main outcomes have core values. It is well known that the scientific research is a continuous mission aimed at the understanding of real life challenges and requires continuous assessment as this study represents.

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Appendix: A

Designed Survey for the efficiency of safety level and reliability engineering in oil construction

The main purpose is to identify the current defects in the risk assessment system of the oil industry, Please tick (✓) near the appropriate answer:

- ***Demographic questions***

Q1- What is your construction company type?

◯ Owners
◯ Vendors
◯ Contractors

Q2- What is your gender?

◯ Male
◯ Female

Q3- What is your age?

◯ Under 20
◯ 20-30
◯ 30-40
◯ 40-50
◯ Above 50

Q4- Please describes your education level:

◯Basic education level
◯Hold a Diploma degree
◯Hold a bachelor degree
◯Hold a Master degree
◯Hold a PhD degree

Q5- What is your job position in the company?

◯ End users

◯ Senior staff

- ***Technical/Procedural/behavioral questions***

Q6- Dose your company has strong HSE management system?

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q 7– You are familiar with risk assessment bases methods.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q8- LTI accidents are always reported in your company.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q9- Your company provides enough training to ensure safety competencies level between its employees.

◯ Strongly Disagree

◯ Disagree
◯ Agree
◯ Strongly agree

Q10- You are familiar with the HSE MS elements of your company.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q11- There are efficient communication channels between the management and the labourers.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q12- Top Management conducts regular safety tours to construction fields.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q13- You understand your role and responsibilities towards safety in your job.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q14- You understand your line supervisors' role and responsibilities towards safety in his job.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q15- Safety policies and procedures are up to date in your company.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q16- Safety policies and procedures are well understood by employees.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q17- You always attended the safety meeting in your department.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q18- Fatality accidents are always reported in your company.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q19- The management provides safe work place for the end users employees.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q20- End users employees face heavy workload pressure in their job.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q21 Risk assessment is fully implemented in construction fields.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q22- There is a poor decision-making due to inadequate risk assessment.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q23- Safety implementation is a direct output of the company's strategic plan.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q24- Your company provides an efficient and effective safety monitoring system towards safety issues at the construction fields.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q25- Safety issues are priority for the management agendas.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q26- There is strict enforcement of safe working procedures and policies.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q 27- Construction workers are well motivated to work safely.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q 28- Audit and inspection are conducted effectively.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q29- Equipment that is used in construction fields are safety inspected.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q30- Your company uses sufficient resources to ensure safety during construction.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q 31- Your company takes disciplinary actions against people violating policies and safety procedures.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q 32- Field Safety supervision is conducted regularly.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q 33- PTW system is always applied before the start of any job in the field.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q 34- Your company's safety management applies continuous improvement concept.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q 35- There is a strong safety culture between the employees at the construction site.
◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q 36- Coaching culture is used at the construction sites.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q 37- Behavioral safety activities are comprehensive and effective.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q 38- The management measures and monitors the Behavioral Based Safety (BBS) in construction sites.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q 39- Construction worker are involved in safety committees and planning.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q 40- Top management actively involved and take direct responsibility of safety incidents.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q 41- : Human factors are always considered in the hazard identification stage.

◯ Strongly Disagree
◯ Disagree
◯ Agree
◯ Strongly agree

Q 42- Which area of safety engineering system in your company requires improvement.

◯ Risk assessment tools
◯ Leadership visibility
◯ Regulations and policies
◯ Behavioral based safety
◯ Others

Q 43- Which one from the following factors could be the most effective one in the safety engineering system implementation.

◯ Poor decision making
◯ Inappropriate allocation of Responsibility
◯ Lack of resources
◯ Lack of experience
◯ Others

Thank you for your time in completing this survey

Appendix: B

Interview for Safety System for Oil and Gas Construction Projects

The main purpose is to identify the top risk factors in the oil and gas construction projects

Q 1: Could you explain and tell your experiences and career leader in oil and construction field?

Q2: Why most of the respondents believe that risk assessment is the weakest element in the safety engineering system?

Q3: As shown in the questionnaires results, many responses believe that there are many safety defects in the safety procedures i.e. understanding and updating them. What do you think about this issue and how we can eliminate and fix it in the construction projects?

Q4: In the questionnaires, most of the responses, managers and workers, admit that there is major challenge towards the implementation of safety culture and Behavioral Based Safety (BBS) Programme in many construction organizations. Why do you think this is happening? How safety culture can be improved in the construction site?

Q5: Equipment failure appears as a main technical safety obstacle that faces the workers in the sites. What do you think about the level of integrity and safety of the used equipment in construction site?

Q6: Do you think there is a need for an integrated model to enhance the application of risk assessment? If yes how it should be applied?

Q7: Do you want to add or comment about the safety engineering system?

Thank you for your time

Appendix: C

Invitation Letter for Framework Evaluation

I am Ghanim Kashwani , Civil Engineering PhD student in school of Energy, Geoscience, Infrastructure and Society (EGIS), Heriot Watt University. As part of my PhD study, I am conducting a research on 'Implementation of Safety Engineering Systems in Oil and Gas Construction Projects in the UAE ' which aims to evaluate the implementation of safety engineering systems in the oil and gas industry construction projects through risk assessment application in the UAE.

The aim of this study is to provide an integrated framework that can optimize the implementation of the safety engineering system through the usage of a risk assessment. Both the questionnaire and the interviews exposed the presently weak areas in the risk assessment application thereby aiding the selection of the framework inputs in this research. There are three main sections employed as filters during the hazard identification stage in which each one of them has specific criteria. Such a focus will facilitate avoiding the kind generalizations practiced in most risk assessment sessions to cover all the possible scenarios that can occur with the existing hazards.

Your participation in the evaluation is very vital for this study due to your industry experience in construction. Interview venue could be any place you feel comfortable. You can also choose a good time to meet. The interview data (and/or any other materials related to the interview) will be kept strictly confidential. Your identity will be protected at all times. Further, you will be requested to verify your interview transcript if you wish to do so.

You can contact me on the details given below. I hope to hear from you soon.

Thanking you.

Best Regards

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